2 MATERIALS

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CHAPTER TWO:
MATERIALS

A HMA pavement is composed of binder and aggregate blended together. The individual material properties of each component may affect the overall performance of the pavement. If pavements are to perform long term and withstand specific traffic and loading, the materials making up the pavements are required to be of high quality.

This section covers in detail the material properties of aggregates, and PG binders that are necessary for high quality pavements. Many of the tests are not required to be conducted by the Technician; however, a thorough understanding of the materials and test procedures to determine quality is a necessary background for the Technician. Converting that understanding into a working knowledge assists the Technician in making accurate, reliable, day-to-day decisions.

AGGREGATES

SOURCES

Aggregates for HMA are generally classified according to their occurrence. The three major sources of aggregates for INDOT use are sand and gravel operations, stone quarries, and industrial processing (synthetic aggregates). Crushed stone, sand, and gravel are classified as natural aggregates. Blast furnace slag, steel slag, granulated blast furnace slag, and wet bottom boiler slag are by-products of industrial processing and are classified as synthetic aggregates.

Sand and gravel generally occur together, where they were deposited by a stream or glacier. These aggregates may be produced either from a water-filled pit using a suction dredge or a crane and dragline bucket, or from a cut-back deposit, using end-loaders or shovels. The raw materials produced in this manner are, therefore, called either pit-run or bank-run materials. These materials require further processing, such as screening, washing and crushing, to produce aggregates of the proper size.

Crushed stone is produced from quarries where bedrock is blasted from a quarry face and then further processed by crushing and screening. Crushing is done by processing the shot rock through a series of crushers until the desired top size is produced. Materials are then graded in a screening operation similar to the sand and gravel operations.

Synthetic aggregates are produced either from blast furnace slag, steel slag, or from wet bottom boiler slag. Blast furnace or steel slag is produced as a by-product of iron or steel production. These materials are non-metallic substances that rise to the surface of molten iron or steel during the smelting process. After being drawn off the surface of the melt, the slag is placed into a pit and is allowed to solidify by the prevailing atmospheric conditions. Granulated slag is blast furnace slag that has been solidified by quickly quenching the material in water. Wet bottom boiler slag is a by-product of coal-fired electric power plants and is commonly known as cinders.

PHYSICAL QUALITIES

Physical quality requirements for aggregates used in HMA are all specification provisions other than those dealing with gradation or usage requirements. These quality requirements may be divided into five distinct groups as follows:

1) Absorption/Specific Gravity

2) Abrasion Resistance

3) Soundness

4) Deleterious Materials

5) Special Requirements

Absorption and Specific Gravity

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid.

Density is the weight per unit of volume of a substance. Specific gravity is the ratio of the density of the substance to the density of water. The following chart illustrates these relationships for some common substances.

Substance	Specific Gravity	Density (lb/ft^3)
Water	1.0	62.4
Binder	1.02	63.7
Limestone	2.7	165 to 170
Lead	11.0	680 to 690

The density and the specific gravity of an aggregate particle is dependent upon the density and specific gravity of the minerals making up the particle and upon the porosity of the particle. These may be defined as follows:

1) All of the pore space (bulk density or specific gravity)

2) Some of the pore space (effective density or specific gravity)

3) None of the pore space (apparent density or specific gravity)

Determining the porosity of aggregate is often necessary, but measuring the volume of pore space is difficult. Correlations may be made between porosity and the bulk, apparent, and effective specific gravities of the aggregate.

As an example, specific gravity information about a particular aggregate helps in determining the amount of binder required in the HMA. If an aggregate is highly absorptive, the aggregate continues to absorb binder after initial mixing at the plant, until the mix cools down completely. This process leaves less binder for bonding purposes; therefore, a more porous aggregate requires more binder than a less porous aggregate. The porosity of the aggregate may be taken into consideration in determining the amount of binder required by applying the three types of specific gravity measurements.

In the example in Figure 2-1, the bulk specific gravity includes all the pores, the apparent specific gravity does not include any of the pores that would fill with water during a soaking, and the effective specific gravity excludes only those pores that would absorb binder.
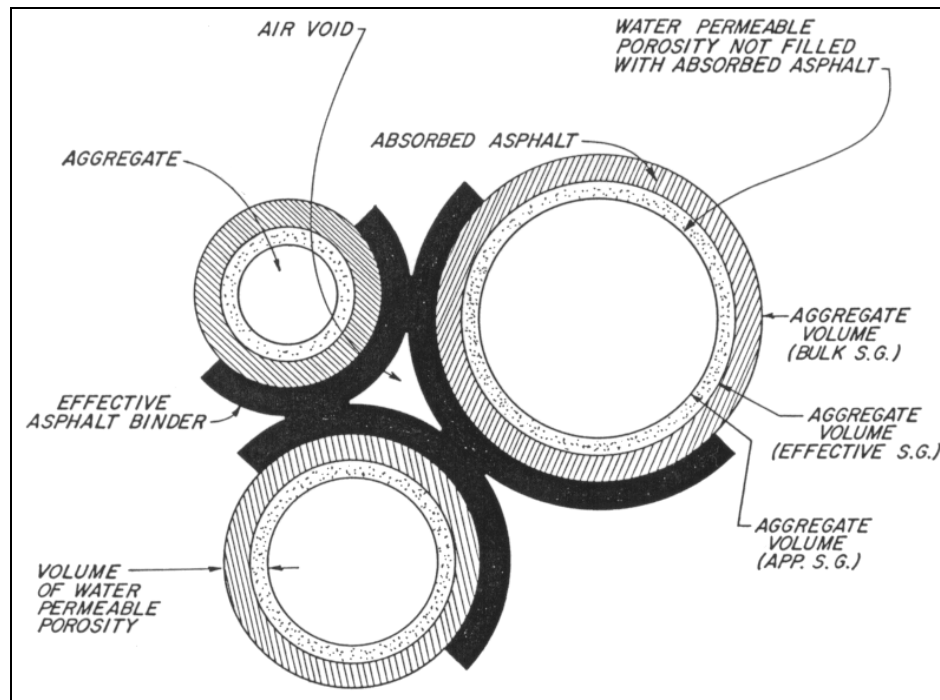
Figure 2-1. Aggregate Specific Gravities

Abrasion Resistance

For a coarse aggregate to be satisfactory for a pavement, the aggregate is required to be tough enough to withstand the action of rolling during construction and the action of traffic without breaking down under the loads. The test used for evaluating this property is the Los Angeles Abrasion test (**AASHTO T 96**). Briefly, this test requires the aggregateto be placed in a metal drum along with a charge of steel balls, and the drum rotated 500 times. The inside of the drum is equipped with an angle iron which runs longitudinally. The angle iron causes the charge of aggregate and balls to fall with a heavy impact once during each revolution, breaking the aggregate particles into smaller particles. At the completion of the test, the aggregate is shaken over a No. 12 sieve and the amount which passes the sieve, expressed as a percentage of the total charge, is the Los Angeles Abrasion value designated "percent wear". Very hard aggregates have values of 20 percent or less; softer aggregates, such as a limestone which may be scratched easily with a pocketknife, may have values over 40 percent. Aggregates, with the exception of Blast Furnace Slag, with a wear of over 40 percent are unsatisfactory for use in surface HMA. Class AS aggregate for use in SMA is required to have a maximum wear of 30 percent. Aggregate used in a base HMA may be softer than used in a surface HMA. The test equipment is illustrated in Figure 2-2.
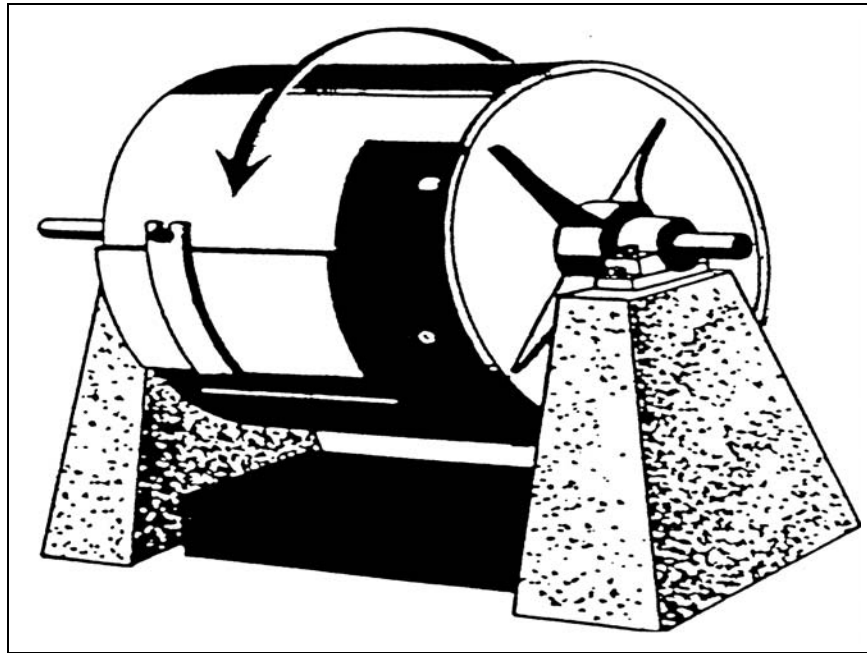
Figure 2-2. Los Angeles Abrasion Apparatus

Soundness

Aggregates which disintegrate badly under the force of weathering are termed unsound. Shale is a typical unsound material because water enters into the aggregate and freezes, causing the aggregate to expand and disintegrate. Also, exposure to air (oxidation) causes shale to flake. Unsound aggregates are obviously unsatisfactory for use in HMA, particularly for surface HMA, which are exposed to the weather. INDOT subjects aggregates to three different test methods to evaluate soundness:

1) The sodium sulfate test in **AASHTO T 104**

2) The brine freezing and thawing test in **ITM 209**

3) The freezing and thawing test in **AASHTO T 103**

The sodium sulfate test requires immersing an aggregate sample in a sodium sulfate solution for a period of time and then determining the weight loss of particles on a given set of sieves. The brine freeze and thaw test requires the aggregate to be enclosed in a bag containing a 3 percent sodium chloride solution and is subjected to 25 cycles of freeze and thaw. The water freeze and thaw test requires the aggregate to be sealed and totally immersed in water and subjected to 50 cycles of freeze and thaw.

The freezing and thawing in water test is the method that most accurately simulates actual field conditions; however, the test requires a long period of time to conduct. The "quick" checks for soundness of the aggregate are the brine freeze and thaw and sodium sulfate tests. If the aggregate fails either the brine freeze and thaw or the sodium sulfate test, the material is tested using the freeze and thaw method with water. An aggregate that reasonably fails the brine freeze and thaw and/or sodium sulfate test but then passes the freeze and thaw in water method is an acceptable material for use on INDOT contracts.

Deleterious Materials

Certain substances such as deleterious materials in aggregates are undesirable for use in HMA. Therefore, the Specifications limit the amount of deleterious materials to a level consistent with the quality required in the final product. Figure 2-3 illustrates the materials which are classified as deleterious and the Specification limits for each. Of particular interest for avoidance in HMA is chert.

Chert is mineral matter composed of microcrystalline silica. When lightweight chert (less than 2.45 specific gravity) is present in aggregate used to produce HMA, the chert may undergo volumetric expansion sufficient to cause disruption of the mix, causing popouts when the chert particles are located close to the surface. In addition, the binder is unable to coat chert particles which may lead to raveling of the pavement under traffic. Once either problem is initiated, the rate of deterioration of the surface is accelerated.
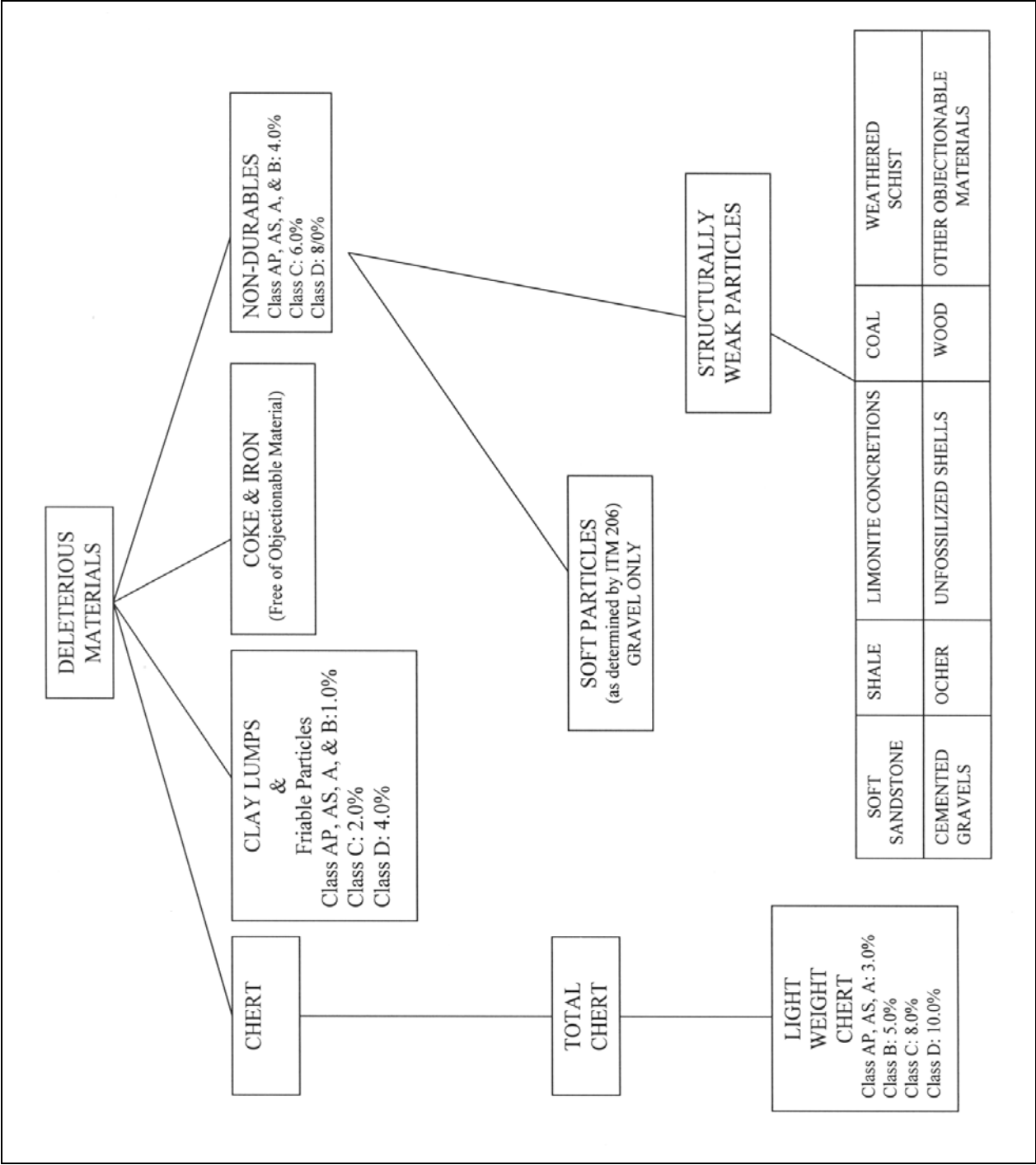
DELETERIOUS MATERIALS

CHERT

CLAY LUMPS & Friable Particles
Class AP, AS, A, & B: 1.0%
Class C: 2.0%
Class D: 4.0%

COKE & IRON
(Free of Objectionable Material)

NON-DURABLES
Class AP, AS, A, & B: 4.0%
Class C: 6.0%
Class D: 8/0%

SOFT PARTICLES
(as determined by ITM 206)
GRAVEL ONLY

STRUCTURALLY WEAK PARTICLES

TOTAL CHERT

LIGHT WEIGHT CHERT
Class AP, AS, A: 3.0%
Class B: 5.0%
Class C: 8.0%
Class D: 10.0%

| SOFT SANDSTONE | SHALE | LIMONITE CONCRETIONS | COAL | WEATHERED SCHIST |
| CEMENTED GRAVELS | OCHER | UNFOSSILIZED SHELLS | WOOD | OTHER OBJECTIONABLE MATERIALS |

Figure 2-3. Deleterious Materials

Particle Shape

The shape of the aggregate particles affects such things as:

1)   The binder demands of HMA

2)   The workability and the strength of HMA

The best aggregates to use for strength are crushed stone or crushed gravel. Crushed aggregates have irregular, angular particles that tend to interlock when compacted or consolidated.

The crushed stone or crushed gravel aggregate make the HMA somewhat difficult to place. To improve the workability, many mixes contain both angular and round particles. The coarse aggregate particles are usually crushed stone or crushed gravel, and the fine aggregate particles are usually natural sand.

Surface Texture

Like particle shape, the surface texture also influences the workability and strength of HMA. Surface texture has often been considered more important than the shape of the aggregate particles. A rough, sandpaper-like surface texture as opposed to a smooth surface tends to increase the strength of the HMA. Some aggregates may initially have good surface texture but under traffic may polish smooth.

Coatings

Coatings are a layer of substance covering a part or all of the surface of an aggregate particle. The coating may be of natural origin, such as mineral deposits formed in sand and gravel by ground water, or may be artificial, such as dust formed by crushing and handling.

Generally, aggregates used in HMA are required to be washed to remove the coating (contaminant) left on the particles. The coating may prevent a good bond from forming between the aggregate surfaces and the binder. The coating could even increase the quantity of binder needed in the HMA. Also, if the quantity of the coating varies from batch to batch, undesirable fluctuations in the consistency of the HMA may result.

Coarse Aggregate Angularity

Crushed particles (coarse aggregate angularity) are necessary in HMA to assist in resisting shoving and rutting under traffic. The internal friction among the crushed aggregate particles prevents the aggregates from being moved past each other and provides for a stable mix. The test procedure used to determine coarse aggregate angularity is **ASTM D 5821**.

The crushed particle requirement applies for HMA when gravel is used. Crushed particles are defined as those particles having one or more sharp, or slightly blunt edges. Fractured faces that have an area less than 25 percent of the maximum cross sectional area of the particle are not considered crushed.

Flat and Elongated Particles

Flat and elongated particles are undesirable because they have a tendency to break during construction and under traffic. This characteristic is defined as the percentage by weight of coarse aggregates that have a length in excess of five times its width in accordance with **ASTM D 4791**. Figure 2-4 is an illustration of the device used to measure flat and elongated particles.
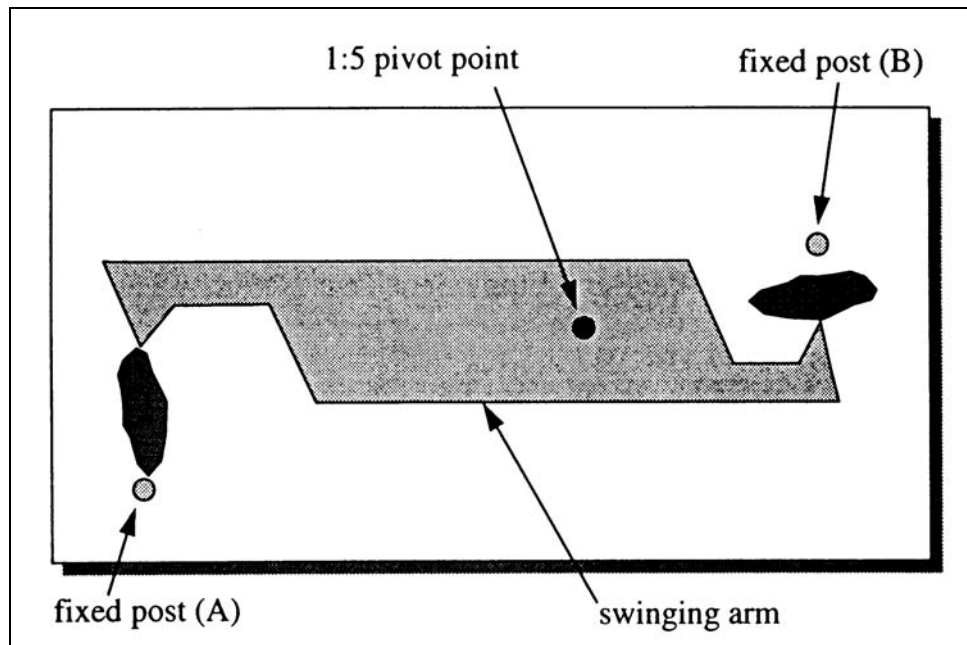

Figure 2-4. Flat and Elongated Particle Test

Limitation of the amount of clay in aggregate strengthens the adhesive bond between the binder and the aggregate. Clay content is the percent of clay material contained in the aggregate fraction that is finer than a No. 4 sieve.

The test used for determining the clay content is the Sand Equivalent Test (**AASHTO T 176**). In this test, a sample of fine aggregate is placed in a graduated cylinder with a flocculating solution and agitated to loosen clayey fines present in and coating the aggregate. The flocculating solution forces the clayey material into suspension above the granular aggregate. After a period that allows sedimentation, the cylinder height of suspended clay and sedimented sand is measured (Figure 2-5). The sand equivalent value is computed as a ratio of the sand to clay height readings expressed as a percentage.
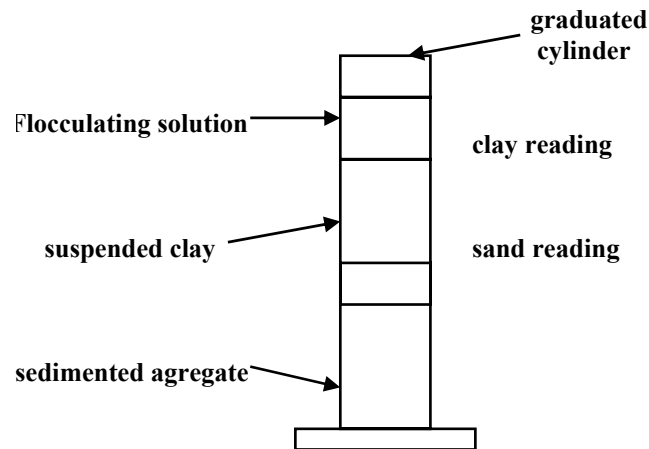

Figure 2-5. Sand Equivalent Test

Fine Aggregate Angularity

Fine aggregate angularity (FAA), like the crushed content of coarse aggregate, is necessary to achieve a high degree of internal friction and therefore high shear strength for rutting resistance. FAA is defined as the percent air voids present in loosely compacted aggregates finer than the No. 8 sieve.

The test used for determining the Fine Aggregate Angularity is the Uncompacted Void Content of Fine Aggregate Test (**AASHTO T 304**). In the test, a sample of fine aggregate is poured into a small calibrated cylinder by flowing through a standard funnel (Figure 2-6). By determining the weight of fine aggregate (W) in the filled cylinder of known volume (V), void content may be calculated as the difference between the cylinder volume and fine aggregate volume collected in the cylinder. The fine aggregate bulk specific gravity (Gsb) is used to compute fine aggregate volume.

funnel

fine aggr sample

cylinder of known volume (V)

uncompacted voids

$$\frac{V - W/G\text{-}sb}{V} \times 100\%$$
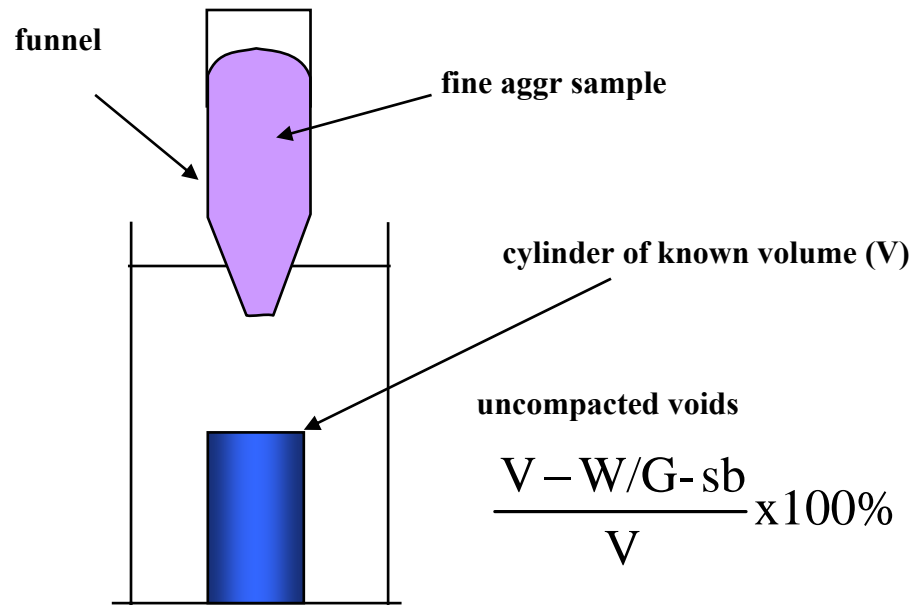
Figure 2-6. Fine Aggregate Angularity

Dolomitic Aggregates

There is a special requirement to be met when dolomitic coarse aggregates are used in HMA. These aggregates are specified under some conditions to obtain high-friction, skid-resistant HMA surface courses. **ITM 205** is used to ensure that the aggregate is a carbonate rock containing at least 10.3 percent elemental magnesium.

Polish Resistant Aggregates

Aggregates that meet the requirements of **ITM 214** may be used in place of dolomitic aggregates in HMA surface mixtures. The procedure for approval requires initial British Pendulum testing, placement of a test section on an INDOT contract, and subsequent skid testing for two years.

Coarse Sandstone is required to meet the Class B quality requirements, and may only be used in HMA surface mixtures. The definition of sandstone is described in Section **904.01**.

Slag Aggregates

When slag is furnished as an alternate to natural aggregate, payment is made on a weight basis. Adjustments are required to be made to compensate for the difference in specific gravity of the slag compared to the specific gravity of the natural aggregate. For any pay item less than 500 t on a contract, no adjustment is made. The following typical values are required to be used.

TYPICAL VALUES FOR SPECIFIC GRAVITY	
Natural aggregates (both fine and coarse)	2.6
Air cooled blast furnace slag coarse aggregate	2.3
Air cooled blast furnace slag fine aggregate	2.6
Granulated blast furnace slag fine aggregate	2.1
Steel furnace slag, both fine and coarse	3.2

Steel furnace slag for use in SMA is required to meet additional requirements for control of the specific gravity in accordance with Section **904.01.**

STOCKPILING

Segregation is probably the greatest problem of stockpiling and handling aggregates, but certainly other problems such as degradation and contamination may adversely affect the aggregate quality. Every possible precaution is required to be taken to protect aggregate quality from initial stockpiling to the point where the material is loaded into the HMA plant.

The majority of aggregate stockpiles at the HMA plant are built by dumping individual truckloads of material. The best truck-built stockpiles are those that are constructed one dump high with each dump placed against previously dumped material. This procedure, because of the low profile, reduces the roll-down segregation; however, these stockpiles require a large area. A technique that helps reduce the required area is to restock some dumps on top of other dumps with a large endloader operating from ground level. In this procedure, care is required to be taken to place the upper lift back from the edge far enough that a long sloped face is not made that would cause segregation.

Occasionally aggregate is dumped over a quarry or pit face to form a stockpile. This procedure causes considerable segregation, particularly with larger and long graded aggregates. In general, the larger particles roll to the outside and base of the stockpile. The extent of segregation varies with the height of fall, gradation of the material, moisture, and other conditions. Segregation typically occurs as shown in Figure 2-7.
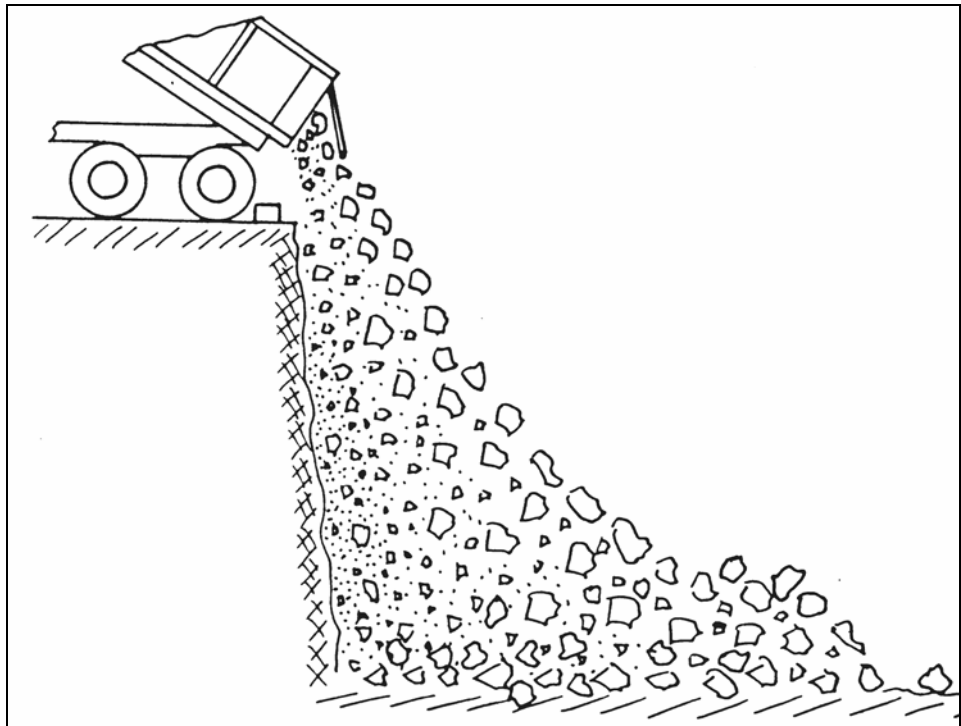

Figure 2-7 Aggregate Segregation

SAMPLING

Because of the various sampling locations and the availability of equipment, there are several methods of taking aggregate samples. Uniformity of obtaining the sample cannot be emphasized enough. The uniformity eliminates one variable in the test results.

Bin Sampling

Bin samples taken at HMA plants are required to be taken at the discharge chute of the bin. In this procedure, a number of small samples are taken at short intervals and combined to make the total sample. Each of these samples are required to include the entire cross section of the flow of material from the chute at the moment taken. If the rate of flow from the discharge chute cannot be controlled, obtaining a sample from the bin may be impractical or impossible. Therefore, a mechanical sampling device that supports the weight of sample or a diversion chute may be required.

Belt sampling material consists of taking samples of materials directly from conveyor belts. The proper procedure is to:

1) Make sure that the belt is carrying a normal load of material which is not segregated

2) Have the plant operator stop the belt

3) Take a complete cross section of the material, being careful to include all the material on the belt and only the material in the section. A template is recommended. Remove most of the sample with a scoop or shovel and the remainder with a brush

4) Take as many complete cross sections as necessary to obtain a sample that meets the minimum sample size

Stockpile Sampling

The primary control of aggregates at the HMA plant is done by sampling stockpiles of the finished materials. Therefore, a uniform and representative method of sampling (**ITM 207**) is required. Coarse aggregate samples are taken with a square bit shovel. The size of the shovel is required to be large enough so that the sample meets the minimum weight requirements of the test conducted on the sample. Fine aggregate samples are taken with a sampling tube or fire shovel.

Coarse aggregate is required to be sampled in the following manner:

1) Locate the area of the stockpile from which plant loading begins

2) Using a front-end loader, dig into the stockpile and set aside a small pile of 10 to 15 t of material. This is required to be done in the same manner as the plant is being loaded. (Figs. 2-8 and 2-9) When forming the small pile, the loader bucket is required to be as low as possible and the operator is required to roll the material from the bucket rather than dumping the material. Reducing the distance the material is allowed to free-fall reduces the amount of segregation that may occur in the small pile (Fig. 2-10). Each additional bucket load of material is required to be taken and dumped in the same manner as set out above and is required to be placed uniformly over the preceding one. (Fig. 2-11)

3)   Thoroughly mix the small pile. Using the loader bucket, go to the end of the oblong pile and roll the material over. Keeping the loader bucket as low as possible, push the bucket into the material until the front of the bucket passes the midpoint of the original pile. The loader bucket is required to then be slowly raised and rolled forward thus producing a smooth mixing of the material. (Figs. 2-12, 2-13, and 2-14) Go to the opposite end of the pile and repeat this mixing procedure. If the pile does not appear to be reasonably uniform, additional mixing is required to be done.

4)   The pile is now ready for sampling. Do <u>not</u> strike off the top. (Fig. 2-15) The sample is taken at the center of the volume which is approximately one-third of the height of the pile. The sample consists of not less than 6 full shovels of material taken at equal increments around the pile (Figs. 2-16, 2-17 and 2-18). The shovel is inserted full-depth horizontally into the material and raised vertically. Care is required to be taken to retain as much of the material as possible on the blade of the shovel. (Fig. 2-19)
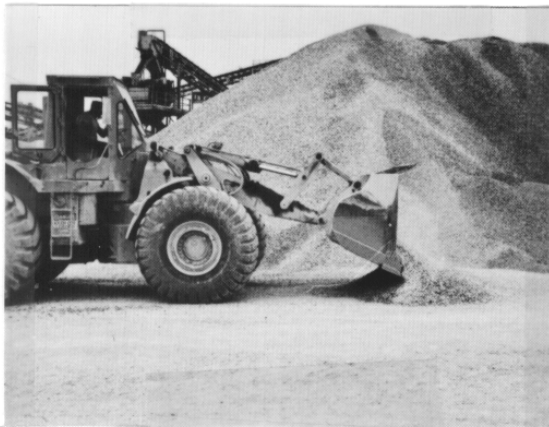
Figure 2-8

Figure 2-9

Figure 2-10

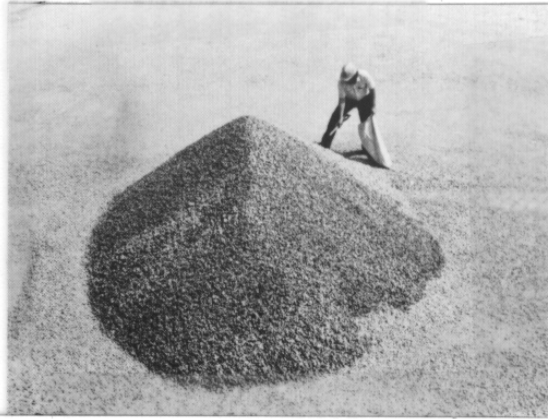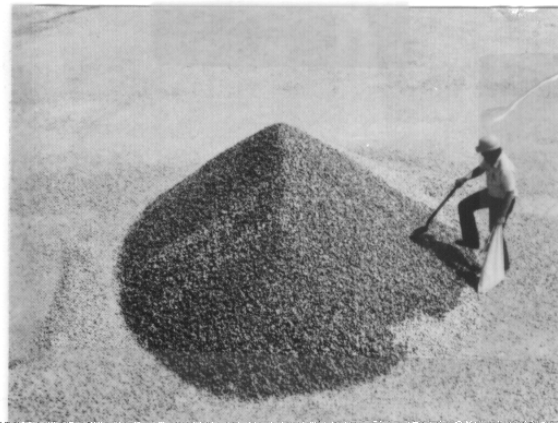Figure 2-11

Figure 2-12

Figure 2-13

Figure 2-14

Figure 2-15

Fine aggregates are sampled using the same technique used to sample coarse aggregates, except a sampling tube or fire shovel is used instead of the large shovel.

Truck, Car, or Barge Sampling

Direct sampling from trucks, railroads cars, or barges is <u>not</u> recommended. There are a number of factors which may influence the quality of the material before the aggregate is used. Therefore, material being shipped by trucks, railroad cars, or barges are required to be sampled at the point of delivery after the aggregate has been stockpiled.

SIZE OF ORIGINAL SAMPLE

The following is a list of recommended minimum sample sizes to be used as a guide when collecting materials.

MATERIAL	SAMPLE SIZE
No. 2 coarse aggregate	220 lb
No. 5 coarse aggregate	110 lb
No. 8 coarse aggregate	55 lb
No. 9 coarse aggregate	35 lb
No. 11 & No. 12 coarse aggregate	25 lb
All sands	25 lb

The weight of the sample depends on the maximum particle size of the material being tested. As a rule, a larger top size material requires a larger sample.   A 35 lb sample of No. 5 coarse aggregate would not be as representative of that material as a 35 lb sample of natural sand. The size of sample for materials that do not meet a specific INDOT size are required to be the same as the INDOT size the aggregate gradation is comparable to.

REDUCING A SAMPLE TO TEST SIZE

The total sample is required to be reduced to a sample size that may be quickly tested.   Time does not allow the Technician to test the total sample. The key to sample reduction is to ensure that the sample remains representative of the material in the stockpile. This practice is commonly referred to as splitting a sample.   There are four different methods to reduce a sample to the proper test size.

1)   Mechanical splitter is the most accepted method of reducing to test size all coarse aggregate material smaller than gradation size No. 2

2)   Sand splitter is the accepted method for fine aggregate that is drier than the saturated-surface-dry condition. As a quick check to determine this condition, if the sand retains the shape that is molded in the hand, the sand is considered wetter than saturated-surface-dry

3)   Miniature stockpile is the method used for fine aggregate that has free moisture on the particle surfaces

4)   Quartering is the method that is used when a mechanical splitter is not available

Mechanical Splitter

The mechanical splitter splits the sample into halves as the material passes through the spaces between the bars in the splitter. The same number of each particle size goes into each half of the sample, thus keeping the reduced sample representative of the total collected sample.

In using the mechanical splitter, the splitter bars are required to be adjusted so that the bar opening is approximately twice the maximum particle size of the material to be split. A No. 5 aggregate has a maximum particle size of 1 1/2 in. Therefore, the recommended bar opening is required to be 3 in. or 6 bars wide (each bar is approximately 1/2 in.). INDOT allows the bar opening at 3 in. (6 bars) for all coarse aggregate No. 5 or smaller. The splitter is required to be level to ensure that each half of the split is approximately the same size; within approximately 10 percent of each other by weight.

The splitting procedure is as follows:

1)   Properly place the pans under the splitter in such a way that all of the particles diverting in both directions are caught

2)   Pour the sample evenly into the hopper

3)   Open the hopper fully and allow the material to free fall through the splitter

4)   If wet particles stick inside the splitter, gently tap the splitter with a rubber hammer to loosen them

5)   To ensure that the sample has not been segregated during sampling, place both halves of the sample back into the hopper and repeat the splitting operation

6) After the second splitting, the two receiving pans will contain approximately the same amount of material. Only one pan is placed back into the hopper and the splitting procedure repeated until a sample of the desired size is obtained. Skillful manipulation of the splitter allows a sample of nearly any size to be made that is still representative of the material in the stockpile.

Sand Splitter

The sand splitter is a small version of the mechanical splitter except that the openings are fixed and there are no hopper doors.

The splitting procedure using the sand splitteris as follows:

1) Place the pans under the splitter to catch all of the particles

2) Slowly pour the dry sample into the splitter from the side (never from the end or corner)

3) Recombine the samples and split the sample a second time to eliminate any segregation

4) Reduce the sample to proper size by additional splitting of the material in one of the pans

Miniature Stockpile

The miniature stockpile method is used for reducing all samples of fine aggregates when the material is in a damp or moist condition. If the sample to be split is dry, the material is required to be moistened before using this method.

The splitting procedure is as follows:

1) Place the original sample on a clean, dry plate or other hard, smooth, non-absorptive surface

2) Using a trowel or other suitable tool thoroughly mix the material to remove any segregation

3) Shape the material into a conical pile

4) With a spoon or small trowel, randomly take at least five small portions of material around the pile and one-third way up the cone until the required test sample is obtained

2-20

Quartering is a non-mechanical method of reducing a sample. This is the best method to be used when a mechanical splitter is not available.

The quartering procedure is as follows:

1) Pour the sample in a conical pile in the center of a clean, dry, steel plate or other hard, smooth, non-absorptive surface

2) Using a large trowel, shovel, or other suitable tool, thoroughly mix the material and reshape the sample into a conical pile

3) Uniformly flatten the pile until the height is approximately equal to one-sixth the diameter

4) With a large trowel or other suitable tool, divide the sample in half by vertically passing the tool through the center of the pile. In a similar manner divide each of these halves into two parts, thus quartering the sample

5) Combine diagonally opposite quarters of the material into two samples. Store one of these two halves. If the remaining material still weighs too much, repeat the entire quartering process until the proper test sample size is obtained.

SIZE OF TEST SAMPLE (AFTER SPLITTING)

The original sample is required to be reduced to test sample size which falls within the minimum and maximum weight in the following table.

AGGREGATE SIZE	MINIMUM (suggested)	MAXIMUM (suggested)
No. 2	11300 g	---
No. 5 and No. 8	6000 g	8000 g
No. 9	4000 g	6000 g
No. 11	2000 g	---
No. 12	1000g	---
Fine Aggregate	300 g	---

Particle gradation is determined by a sieve or gradation analysis of aggregate samples. A sieve analysis requires passing the sample through a series of sieves, each of which has openings of specific sizes (Figure 2-20). Sieves are designated by the size of their openings. Coarse particles are trapped in the upper sieves; medium-sized particles pass through to the mid-level sieves; fines pass through to the lowest sieves.

The aggregate gradation considers the percentage by weight of the total sample that passes through each sieve. This is determined by weighing the contents of each sieve following the sieve analysis, then calculating the percentage passing each sieve.
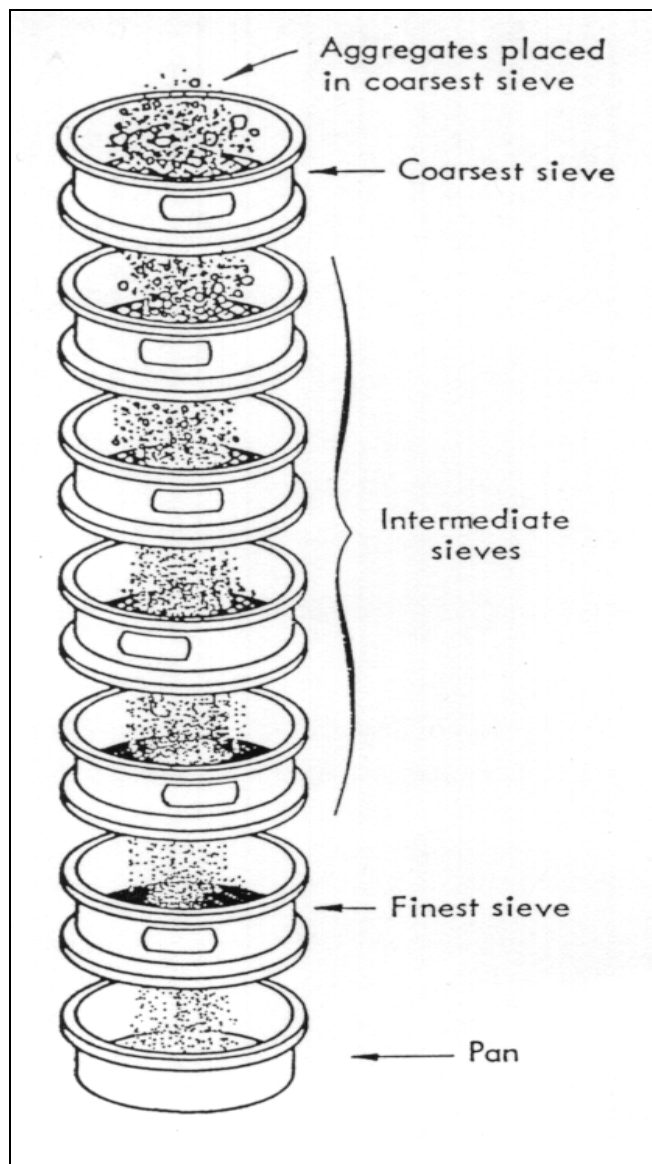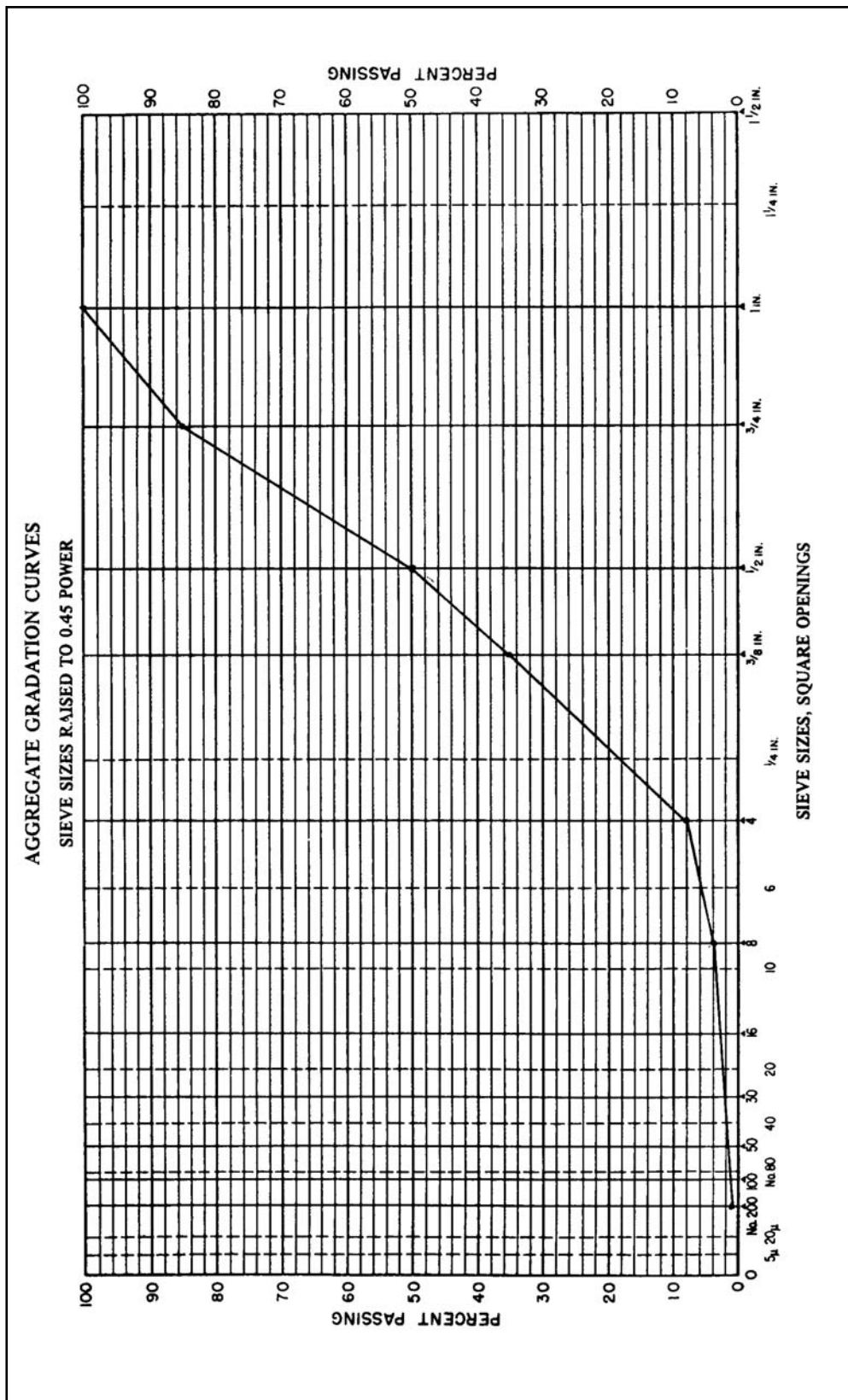

Figure 2-20. Sieve Analysis

Figure 2-21. Gradation Chart

For the purpose of description, certain terms are used in referring to aggregate fractions. They are:

Coarse aggregate - Material that has a minimum of 20 percent retained on the No. 4 sieve

Fine aggregate - Material that is 100 percent passing the 3/8 in. sieve and a minimum of 80 percent passing the No. 4 sieve

Nominal Maximum Particle Size - Smallest sieve opening through which the entire amount of the aggregate is permitted to pass

Maximum Particle Size - Largest sieve size listed in the Specifications through which all material is required to pass

Aggregate gradation specifications for a given contract may be presented graphically. Figure 2-21 is a typical gradation chart. On the chart, sieve sizes are presented horizontally and the percent passing each sieve is shown vertically.

Sieve Analysis Test

Sieve analysis is used primarily to determine the particle-size distribution of materials. The results determine compliance of the particle-size distribution with the applicable requirements. The test is conducted on both the fine and coarse aggregates in accordance with **AASHTO T 27**, with exceptions as noted in Section **904.06**.

The procedure for a sieve analysis is as follows:

1) The dried sample is placed in the top sieve of properly nested sieves. The sieves are nested in sequence with the smallest sieve placed on the pan and stacked by increasing size.

2) The shaking time is required to be sufficient to ensure that the sample is divided into fractional sizes. The actual shaking time is required to be determined in accordance with **ITM 906**. The following times are minimum for shakers:

Coarse Aggregate, Size 9 or larger   5 Minutes
Coarse Aggregate, Smaller than Size 9   10 Minutes
Fine Aggregates   15 Minutes

3)   At the conclusion of sieving, the material retained on each sieve is carefully transferred to a weigh pan and weighed. The weight retained of the material on each sieve is recorded on the Gradation Analysis sheet. The weight may not exceed the allowable amount on each sieve as indicated in Table 1.

The larger sieves (above the No. 16) are cleaned with a small trowel or piece of flat metal. The sieves between the No. 16 and No. 50 are cleaned with a wire brush. Sieves under the No. 50 are cleaned with a soft bristle brush. Care is required to be taken not to damage the sieves.

4)   The weight passing each sieve is calculated next by subtracting the weight retained on the largest sieve from the total sample weight. The weight retained on the next largest sieve is subtracted from the weight of material still remaining from the first subtraction. This process is continued for all sieves.

Example:

1 in.	5942.1 - 690.6	=	5251.5
3/4 in.	5251.5 - 2492.7	=	2758.8
3/8 in.	2758.8 - 1397.1	=	1361.7
No. 4	1361.7 - 997.0	=	364.7
No. 8	364.7 - 264.5	=	100.2
Pan material		=	88.1

TABLE 1 APPROXIMATED SIEVE OVERLOAD				
SCREEN SIZE	STANDARD 15 in. x 23in.	STANDARD 14 in. x 14 in.	12 in. DIAMETER	8 in. DIAMETER
3 in.	40.5 kg	23.0 kg	12.6 kg	--------------
2 in.	27.0 kg	15.3 kg	8.4 kg	3.6 kg
1-1/2 in.	20.2 kg	11.5 kg	6.3 kg	2.7 kg
1 in.	13.5 kg	7.7 kg	4.2 kg	1.8 kg
3/4 in.	10.2 kg	5.8 kg	3.2 kg	1.4 kg
1/2 in.	6.7 kg	3.8 kg	2.1 kg	890 g
3/8 in.	5.1 kg	2.9 kg	1.6 kg	670 g
No. 4	2.6 kg	1.5 kg	800 g	330 g
8 in. diameter sieves, No. 8 to No. 200 shall not exceed 200g / sieve				
12 in. diameter sieves, No. 8 to No. 200 shall not exceed 469g / sieve				

TOTAL WEIGHT:	5942.1g			

SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0 g	5942.1 g	%	%
¾ in.	690.6 g	5251.5 g	%	%
½ in.	2492.7 g	2758.8 g	%	%
⅜ in.	1397.1 g	1361.7 g	%	%
No. 4	997.0 g	364.7 g	%	%
No. 8	264.5 g	100.2 g	%	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	88.1 g	g	%	%

DECANT		GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
ORIGINAL	FINAL			
g	g	g	%	%

5)   The percent passing is calculated for each sieve by using the following formula:

% Passing = $\dfrac{\text{Weight passing each sieve}}{\text{Original dry sample weight}}$ x 100

Example:

3/4 in. $\dfrac{5251.5}{5942.1}$ x 100   =   88.4%

1/2 in. $\dfrac{2758.8}{5942.1}$ x 100   =   46.4% etc.

6)   If the test has been done accurately, the sum of all the fractional weights retained (including the material in the pan) is approximately equal to the original dry weight. If the two weights differ by more than 0.3 percent, based on the original dry sample weight, the results are considered invalid.

$\dfrac{\text{Original Dry Weight - Summation Weights Measured}}{\text{Original Dry Weight}}$ x100

Example:

$\dfrac{5942.1 - (690.6 + 2492.7 + 1397.1 + 997.0 + 264.5 + 88.1)}{5942.1}$ x 100 =

0.2% = valid test

TOTAL WEIGHT:	5942.1g			
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	g	g	%	%
1 in.	0 g	5942.1 g	100 %	%
¾ in.	690.6 g	5251.5 g	88.4 %	%
½ in.	2492.7 g	2758.8 g	46.4 %	%
⅜ in.	1397.1 g	1361.7 g	22.9 %	%
No. 4	997.0 g	364.7 g	6.1 %	%
No. 8	264.5 g	100.2 g	1.7 %	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	88.1 g	g	%	%
DECANT **ORIGINAL**	**FINAL**	**GRAMS LOSS**	**PERCENT LOSS**	**PERCENT REQUIRED**
g	g	g	%	%

When aggregates are obtained from the cold feed belt or the belt discharge for a drum mix HMA plant, the moisture of the aggregates is required to be determined to adjust aggregate weights for moisture content and to determine the amount of binder to add to the HMA.

For moisture content, the sample is required to be reduced to test size and the test conducted as quickly as possible after the sample has been taken. Any delay in conducting the test after the sample has been obtained may allow the material to lose moisture and cause inaccurate results.

The test procedure for moisture content is:

1)   Weigh the sample before drying and record the weight

2)   Dry the sample and allow to cool to room temperature

3)   Weigh the sample and record the weight

4)   Determine the moisture percent using this formula:

$$\% \text{ Moisture} = \frac{\text{Weight Wet - Weight Dry}}{\text{Weight Dry}} \text{ x } 100$$

ASPHALT

Asphalt is a black, cementing material that varies widely in consistency from solid to semisolid (soft solid) at normal air temperatures. When heated sufficiently, asphalt softens and becomes a liquid, which allows the asphalt to coat aggregate particles during HMA production.

Asphalt is made up largely of a hydrocarbon called bitumen. Consequently, asphalt is often called a bituminous material. Virtually all asphalt used in the United States is produced by modern petroleum refineries and is called petroleum asphalt. The degree of control allowed by modern refinery equipment allows the production of asphalts with specific characteristics suited to specific applications. As a result, different asphalts are produced for paving, roofing and other special uses.

Paving asphalt, commonly called binder, is a highly viscous (thick), sticky material. The asphalt adheres readily to aggregate particles and is therefore an excellent cement for binding together aggregate particles in HMA. The binder is a waterproofing material and is unaffected by most acids, alkalies (bases) and salts. This means that a properly constructed HMA pavement is waterproof and resistant to many types of chemical damage.

Binder for paving may also contain modifiers to improve performance properties. Some of these binders require special storage and handling. The material suppliers recommendations are required to be followed to insure that these performance characteristics are not altered or lost before mixing and placement of the HMA.

Binder changes when heated and/or aged. The binder tends to become hard and brittle and therefore lose some ability to adhere to aggregate particles. These changes may be minimized by understanding the properties of the binder and taking steps during construction to ensure that the finished pavement is built in a way that retards the aging process.

SOURCE AND NATURE OF ASPHALT

Because asphalt is used for many purposes, there is sometimes confusion about where asphalt comes from, how asphalt is refined, and how asphalt is classified into grades. There is similar confusion about terms related to asphalt properties and use.

Petroleum Refining

Crude petroleum is refined by distillation, a process in which various fractions (products) are separated out of the crude. Distillation is accomplished by raising the temperature of the crude petroleum in stages. As shown in Figure 2-22, different fractions separate at different temperatures.

The lighter fractions are separated by simple distillation. The heavier distillates, often referred to as gas oils, may be separated only by a combination of heating and applying a vacuum. The product that cannot be distilled under vacuum distillation is asphalt.

Figure 2-23 is a schematic illustration of a typical refinery that indicates the flow of petroleum during the refining process.

Asphalt Refining

Different types of asphalt are required for different applications. To produce asphalts that meet specific requirements, refiners are required to control the properties of the asphalts they produce. This is often done by blending crude petroleums of various types together before processing. Blending allows refiners to combine crudes that contain asphalts of varying characteristics in such a way that the final product has exactly the characteristics required by the asphalt user.

Once the crude petroleums have been blended together, vacuum distillation and solvent extractions are the two widely used processes by which asphalt may be produced.

As discussed above, vacuum distillation requires separating the asphalt from the crude by applying heat and a vacuum. In the solvent extraction process, additional gas oils are removed from the crude, leaving residual asphalt.
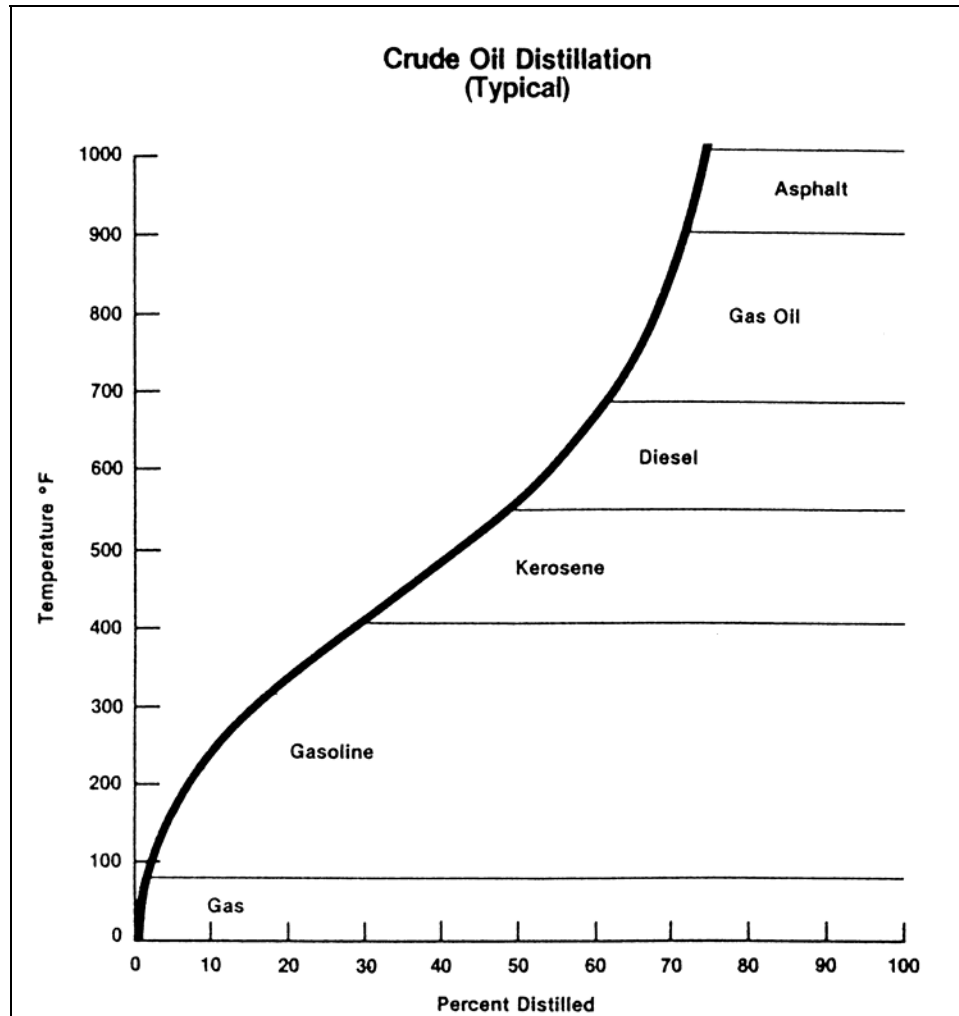

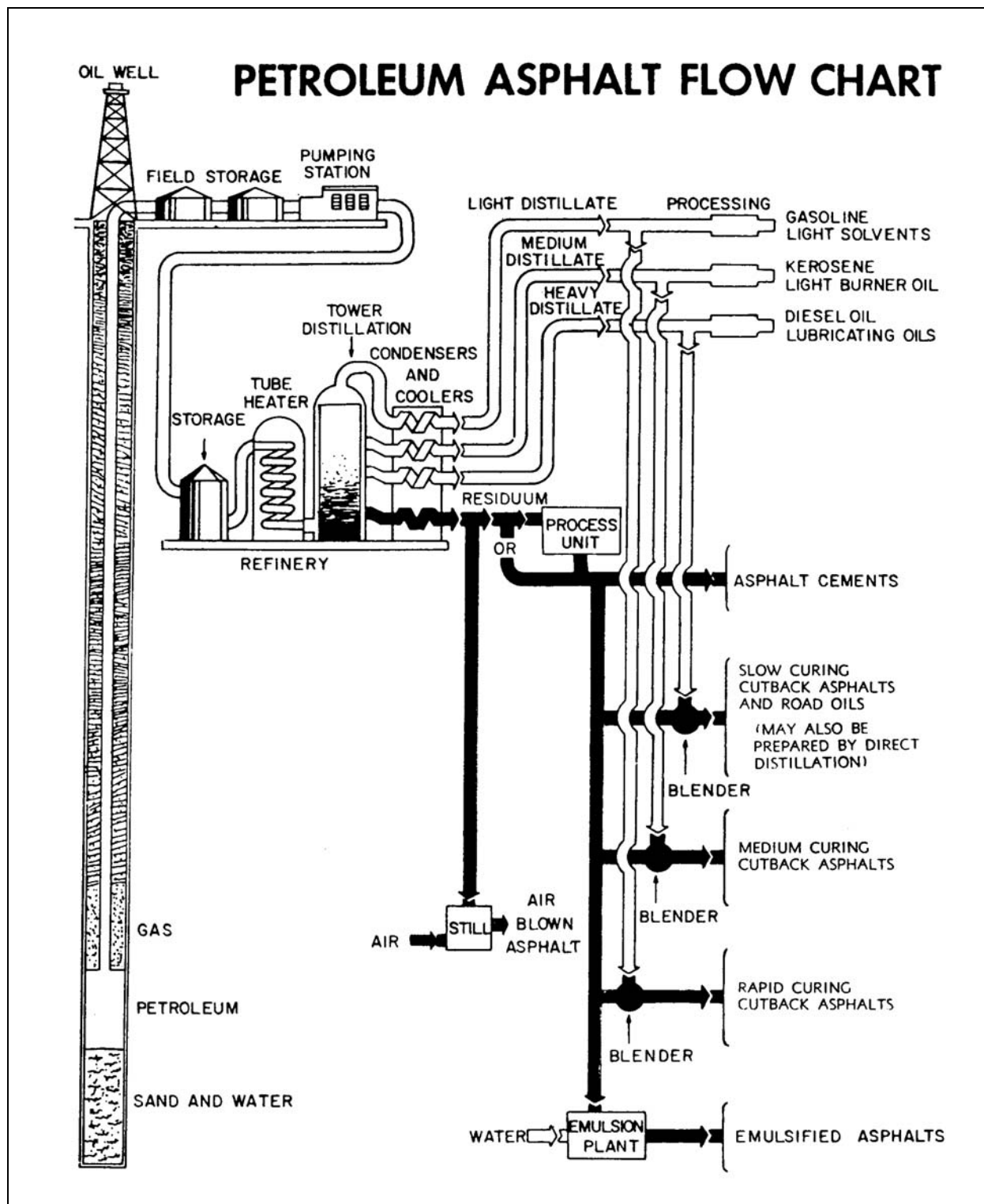**Figure 2-22. Typical Distillation Temperatures and Products**

PETROLEUM ASPHALT FLOW CHART

Figure 2-23. Typical Refining Process

In 1987, the Strategic Highway Research Program (SHRP) began developing a new system for specifying asphalt materials. The final product of the SHRP asphalt research program is a system called Superpave, short for Superior Performing Asphalt Pavements. Superpave represents an improved system for specifying binder and mineral aggregates, developing HMA designs, and analyzing and establishing pavement performance prediction. The system includes a binder specification, a HMA design and analysis system, and computer software that integrates the system components. The unique feature of the Superpave system is that the system is a performance-based specification system. The tests and analyses have direct relationships to field performance.

The SHRP binder specifications are based on fundamental properties which are measured at actual in service temperatures where the critical distresses occur. The upper temperature extreme is designated as the average 7-day maximum pavement design temperature. This temperature is obtained by accumulating the temperature from each successive 7-day period throughout the summer, and selecting the 7-day period which yields the largest average. The lower temperature extreme is designated as the minimum pavement design temperature. The temperatures for the specification were determined by obtaining data from more than 1,000 weather stations. An example of how this grading system works is indicated in Figure 2-24. The specification limits for the PG Binders are listed in Section **902.01**.
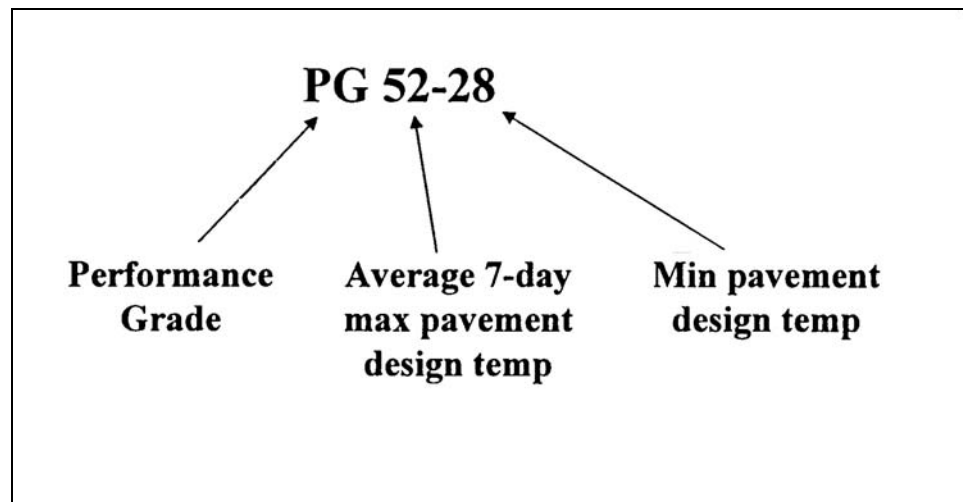

Figure 2-24. PG Grading System

The PG asphalt binder specification is based on the following tests:

1)   Aging

2)   Dynamic Shear

3)   Direct Tension

4)   Bending Beam

5)   Viscosity

6)   Flash Point

Asphalt Binder Aging

Aging evaluation of the binder is conducted by both the Rolling Thin Film Oven (RTFO) (Figure 2-25) and Pressure Aging Vessel (PAV) (Figure 2-26). The RTFO test is to be conducted in accordance with **AASHTO T 240** to simulate aging that occurs during construction.
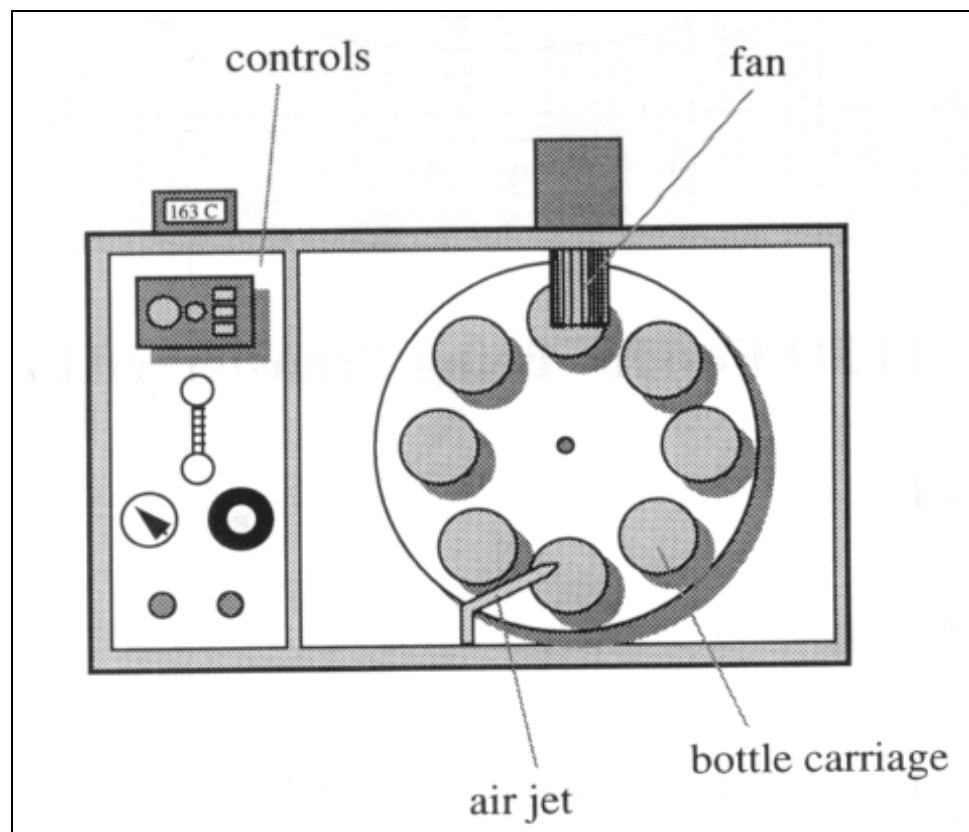

Figure 2-25. Rolling Thin Film Oven (RTFO)

The PAV test (**AASHTO R 28**) is designed to simulate long-term in-service aging (8-10 years), and thereby provide a procedure to estimate the binder properties after aging. The PAV uses a pressurized container into which pans containing RTFO residue binders are placed. Samples in the PAV are subjected for 20 hours to a specified pressure and to variable temperatures depending on the climate of the region.
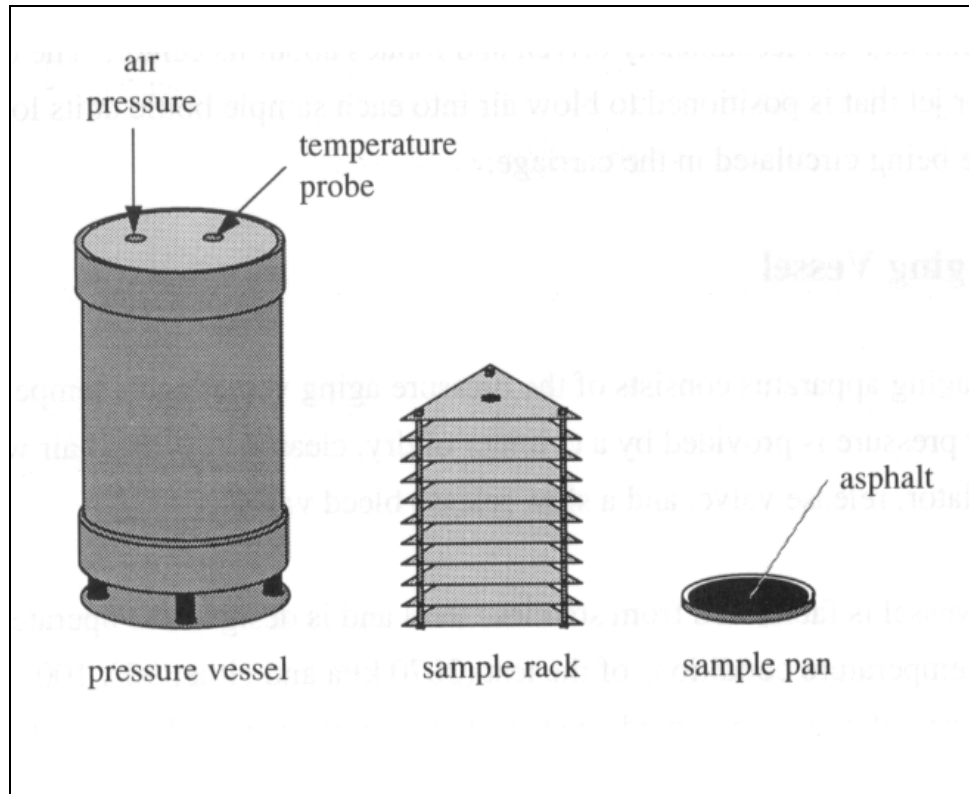

Figure 2-26. Pressure Aging Vessel

The dynamic shear test (**AASHTO T 315**) provides data on the visco-elastic or rheological properties of the binder. Rheology is defined as "the study of deformation and flow of matter", in this case binder. The Dynamic Shear Rheometer (DSR) is used to evaluate binders at upper and intermediate service temperature ranges, where rutting and fatigue are the respective primary distress mechanisms. Although rutting and fatigue cracking properties of HMA are not controlled solely by the binder, the information generated from this test is valuable in obtaining a better understanding of the visco-elastic properties of the binder. Figure 2-27 gives a schematic view of how the DSR functions.
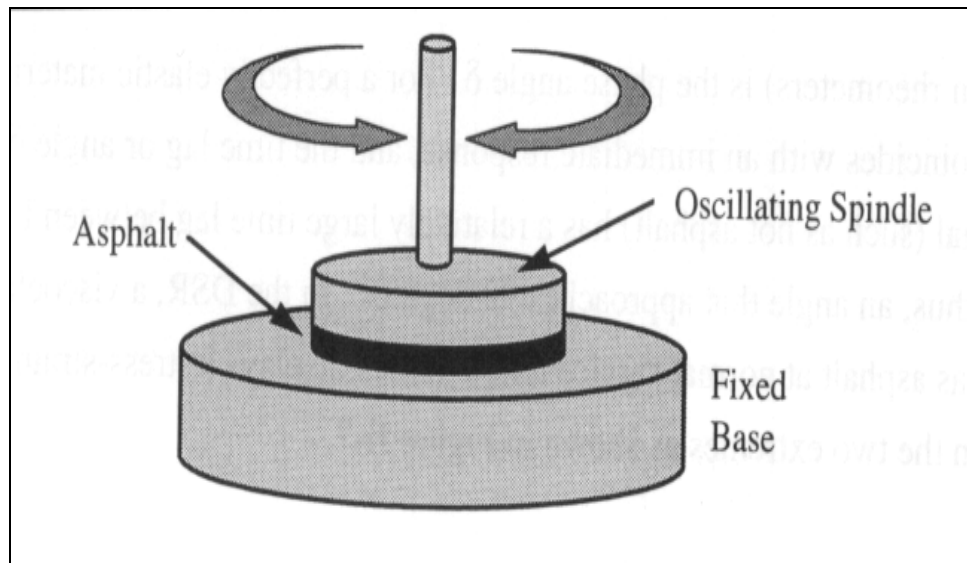

Figure 2-27. Dynamic Shear Rheometer

Direct Tension

The direct tension test (**AASHTO T 314**) pulls a "dogbone" shaped specimen of binder to failure at a controlled rate of "stretching" or strain. The maximum load to failure (failure stress), as well as the maximum amount of stretch to failure (failure strain), are recorded. The test is used to estimate low temperature failure properties of the binder. A drawing of the test specimen is shown in Figure 2-28.
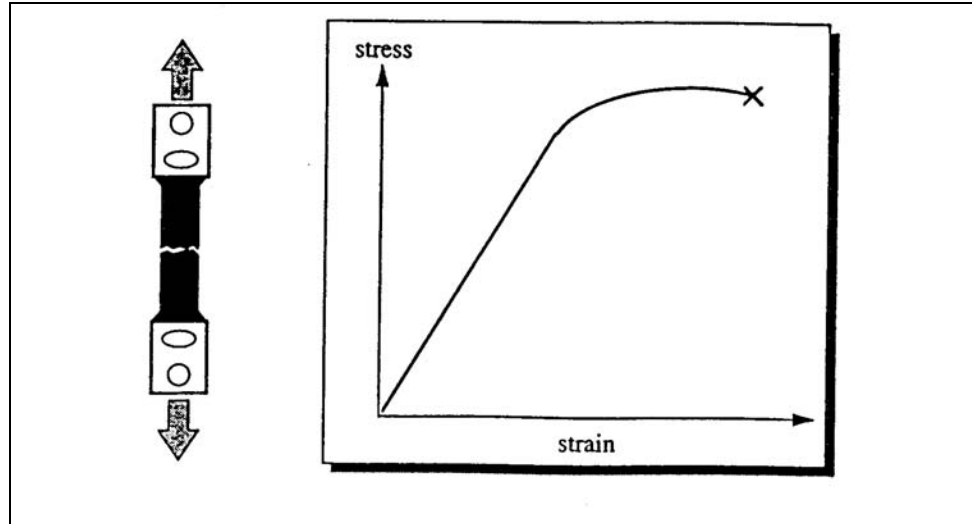
Figure 2-28. Direct Tension

Bending Beam

Low temperature stiffness of the binder is evaluated using the bending beam rheometer. A constant load is applied to a beam sample of the binder which is submerged in a bath. Deflections of the beam are measured and a stiffness versus time curve is developed.

Data generated from this test (**AASHTO T 313**) relates to low temperature thermal cracking. Figure 2-29 provides a schematic view of the test apparatus.
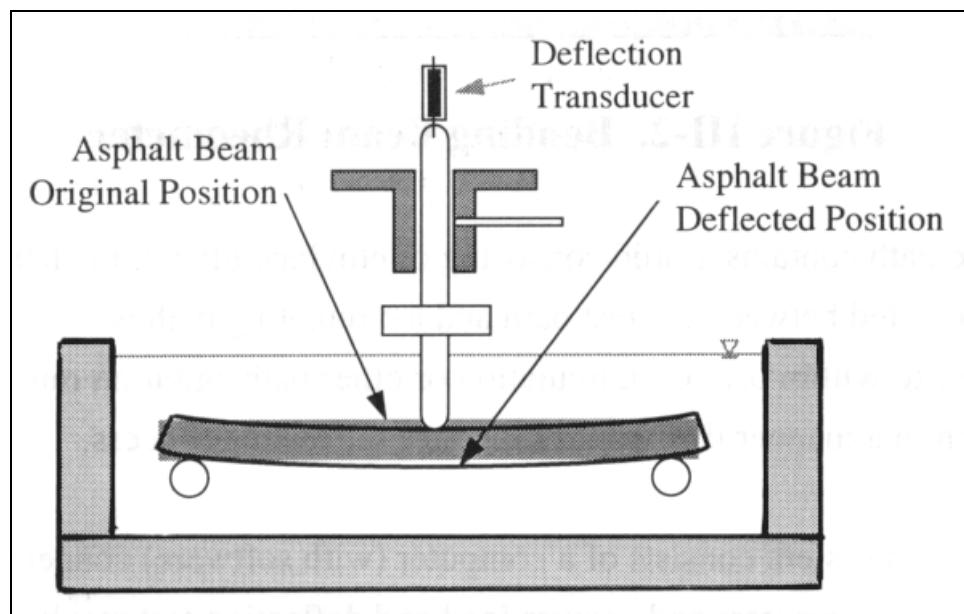

Figure 2-29. Bending Beam

The rotational viscosity test (**AASHTO T 316**) consists of turning a spindle in a sample of binder and reading viscosity as the resistance to movement of the spindle. The test is conducted at high temperatures to ensure proper handling of the binder. A low temperature test may also be conducted to develop a viscosity-temperature curve. This curve may then be used to develop mixing and compaction temperatures for the specific binder. Figure 2-30 illustrates the test apparatus.
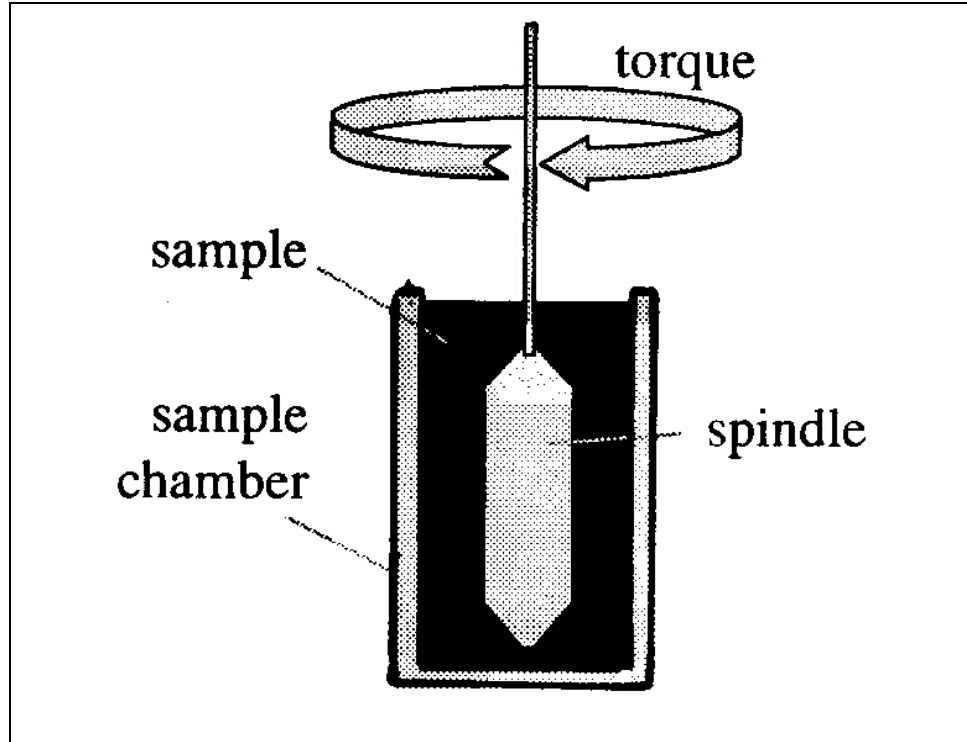

Figure 2-30. Brookfield Viscometer

Flashpoint

The flashpoint of a binder is the lowest temperature at which volatile materials separate from a sample in sufficient concentration to "flash" in the presence of an open flame. Flashpoint is not to be confused with firepoint, which is the lowest temperature at which the binder catches fire and burns. Flashpoint requires only instantaneous combustion of the volatile fractions separating from the binder.

The flashpoint of a binder is determined to identify the maximum temperature at which the binder may be handled and stored without danger of flashing. This is important information since the binder is usually heated in storage to keep the viscosity low enough so that the binder may be pumped.

The procedure for determining flashpoint is to gradually heat a sample of binder in a brass cup while periodically holding a small flame over the surface of the sample (Figure 2-31). The temperature at which an instantaneous flashing of vapors occurs across the surface is taken to be the flashpoint. The Cleveland Open Cup Test (**AASHTO T 48**) is the procedure for determining the flashpoint.
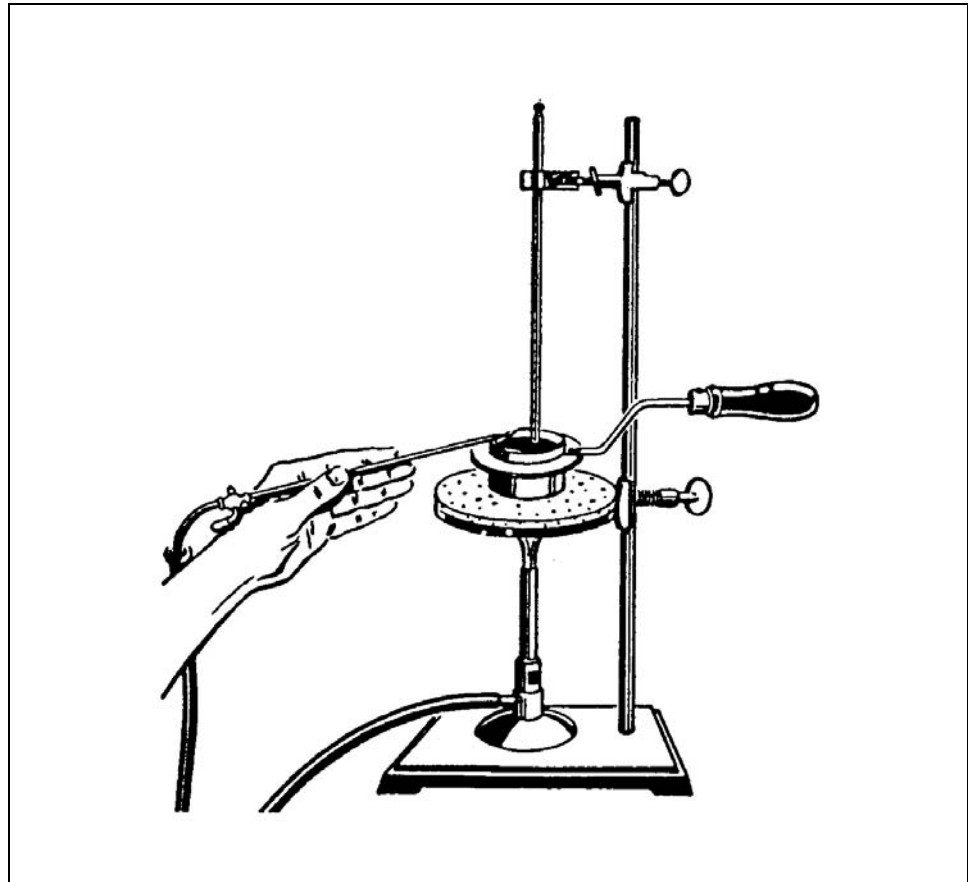

Figure 2-31. Flashpoint Test; Cleveland Open Cup Test

ASPHALT HANDLING, STORAGE, AND SAMPLING

The safety record for handling, storing and sampling asphalt materials is good. Nonetheless, there have been accidents resulting in property damage, personal injury, and loss of life. To prevent such mishaps, the Technician is required to know and follow good safety practices. When an accident does occur, the Technician is required to know how to react and what first aid treatment is appropriate.

The Technician is required to also be aware of the potential sources of contamination that may exist where asphalt materials are stored or handled. Changes in volume that the asphalt material undergoes when heated or cooled are required to also be understood. This knowledge is especially important when comparing asphalt material quantities measured at different temperatures.

HANDLING

At a HMA plant, asphalt material temperatures may exceed 300° F. Metal surfaces of plant equipment often range between 150° F and 200° F. Consequently, momentary contact with hot asphalt materials or with plant equipment, including tanks, pipelines, dryers, boilers, and boiler houses, may cause severe burns to exposed flesh. Four general precautions against such burns are:

1)   Be aware of where burn hazards are located

2)   Use designated walk areas and stay clear of hazardous situations

3)   Always wear appropriate work clothing

4)   Know and follow all plant safety procedures related to handling hot material and equipment

If a burn does occur, follow these general treatment guidelines:

1)   In the case of local asphalt material skin burns, apply cold water or an ice pack to reduce the heat in the asphalt material and the skin

2)   In cases where burns cover more than 10 percent of the body (approximately the skin area of one arm or half a leg), apply lukewarm water instead of cold water. Lukewarm water reduces the temperature of the asphalt material and skin without causing shock, which may be induced by applying cold water or ice to major burns.

3)   Do not remove the asphalt material from the skin

4)   Do not cover the burned area with a bandage

5)   Have a physician examine the burn immediately

Hydrogen sulfide is a product of the reaction between hydrogen and sulphur naturally present in asphalt materials. In low concentration, hydrogen sulfide is not dangerous; however, in the concentrations sometimes found in storage tanks and other closed areas, hydrogen sulfide may be lethal. To prevent overexposure to hydrogen sulfide fumes, follow these guidelines:

    1)   Keep your face at least two feet away from asphalt material tank hatch openings

    2)   Stay upwind of open hatches

    3)   Avoid breathing fumes when opening hatch covers or taking samples

In case of overexposure to hydrogen sulfide fumes, do the following:

    1)   Move victim immediately to fresh air

    2)   Administer oxygen if breathing is difficult

    3)   Start artificial respiration if breathing stops

    4)   Have the victim examined by a physician immediately

Figure 2-32 includes first aid information for asphalt burns.

FIRST AID
FOR MOLTEN ASPHALT CEMENT BURNS

In the event of a MOLTEN ASPHALT CEMENT BURN:

COOL the asphalt cement and affected parts of the body immediately.

Methods of cooling (in order of preference):
1. Completely submerge affected area in ice water;
2. Completely submerge affected area in tap water;
3. Place affected area under running water.

DO NOT DELAY

Use any available water, cooler than body temperature, while arranging for better cooling.

CAUTION: DO NOT apply ice directly to affected area.
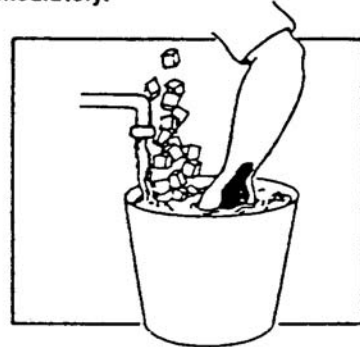
LEAVE cooled asphalt cement on affected area.

Proceed with the following:

MINOR ASPHALT CEMENT BURNS—at first opportunity get victim to physician.
   Includes:
   Injury to small areas of fairly insensitive flesh
   Involving a small quantity of asphalt cement.
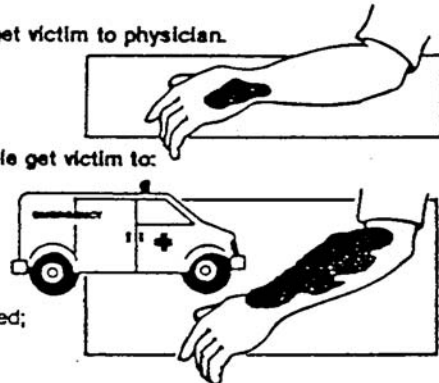
SERIOUS ASPHALT CEMENT BURNS—as soon as possible get victim to:
   Hospital _____
   Clinic _____
   Physician's Office _____

   Includes:
   Injury to the head, face or extremities;
   Injury when large amounts of asphalt cement are involved;
   Evidence of nausea or faintness.

TREATMENT FOR SHOCK

In the event shock occurs, do the following:
1. Keep victim lying down and quiet.
2. Keep victim covered with a blanket or something similar to keep body temperature at normal, 98°F (37°C).
3. Keep victim's head lower than feet to promote blood supply to head and chest.

DO NOT ATTEMPT TO REMOVE THE ASPHALT CEMENT with products containing solvents or ammonia.
Natural separation will occur in about 48–72 hours.
If necessary, for early removal, soak bandage in mineral oil and place over affected area for 2 to 3 hours.
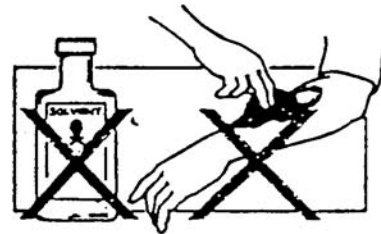
Figure 2-32. First Aid for Asphalt Burns

The Technician is not required to test the binder or asphalt emulsion for Specification purposes. However, the Technician is required to be aware that these materials are tested for compliance from the HMA plant and not the asphalt refinery. Therefore, the Technician is required to know what plant conditions may change the physical properties of these materials and possibly cause the materials to become out of Specifications.

Three major problems may cause the asphalt binder to be outside of the Specifications. The first is contamination. If hot oil is used to heat the binder tank, then any leak in the system may contaminate the binder. The contamination results in a lower viscosity binder. Another source of contamination is fuel oil. If binder is contaminated with significant quantities of fuel oil because of flushing pumps and lines, then the binder stiffness drops.

A second and more prevalent problem is the effect that extended heating in storage tanks has on the binder. When binder is heated, the binder slowly increases in stiffness. The rate of change in viscosity is dependent on the size of tank, surface area, amount of circulation, temperature, etc. The problem of compliance with the Specifications generally is found after long rainy periods with extended heating. Failures may be minimized by reducing heating and circulation during these periods of non-production. When the Technician has some doubts about the material, the binder is required to be tested to determine compliance. This greatly minimizes the number of problems and penalties associated with failures.

A third problem encountered with binder is improper storage. Modified binders include additives to improve (extend) the grade to encompass a wider temperature range for performance. Many of these modified binders are required to be stored under special conditions to maintain their properties. Material supplier recommendations for storage and handling are required to be followed.

Normally binder samples are taken from a sampling valve on a storage tank. A few important rules to follow when sampling the binder are:

1)   To ensure that samples are representative of the entire shipment, take the samples from the sampling valves provided for that purpose (Figure 2-33). Dip samples taken from the top of a tank are not normally representative. Other sampling methods are described in **AASHTO T 40.**

2)   Use only new, clean dry sample containers

3)   Allow at least 4 quarts of the binder to drain out of the valve before taking samples. This draining cleans out the valve and the lines and helps to provide a representative sample.

4)   Seal filled containers immediately with clean, dry, tight fitting lids. Wipe any spilled material from the container with a clean, dry cloth; never with a cloth dipped or soaked in solvent.

5)   Label all containers clearly. Do not label container lids, because once the labeled lid is removed, identifying the sample in the container is difficult. Do all labeling with a wick marking pen. Use tags only when there is no danger of the tags being lost in transit.

6)   Follow all safety precautions for handling and storing hot binder. The binder is hot when sampled; therefore, protective clothing (gloves, face shield, long-sleeved shirt) to protect from burns and splattering is required.
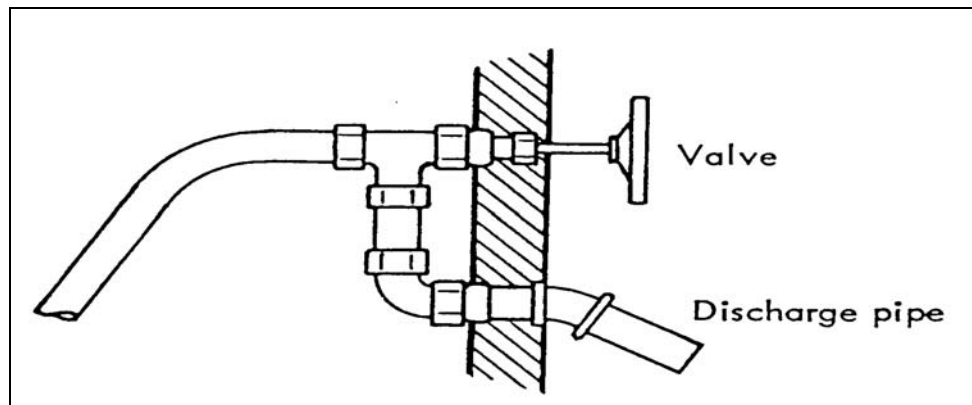

Figure 2-33. Sampling Device for Storage Tanks

BINDER VOLUME

SPECIFIC GRAVITY

Specific gravity is the ratio of the weight of a volume of material to the weight of an equal volume of water, both at a specified temperature. As an example, a substance with a specific gravity of 1.6 weighs 1.6 times as much as an equal volume of water.

Knowing the specific gravity of the binder being used is important for two reasons. First, binder expands when heated and contracts when cold. This means that the volume of a given amount of binder is greater at higher temperatures than at lower temperatures. Specific gravity measurements provide a yardstick for making temperature-volume corrections.

Second, specific gravity of the binder is essential in the determination of the percentage of voids (air spaces) in the compacted pavement.

Specific gravity is usually determined by the pycnometer method as shown in Figure 2-34. Because specific gravity varies with the expansion and contraction of binder at different temperatures, results are normally expressed in terms of Specific Gravity at a given temperature for both the material and the water used in the test. (Example: Sp.Gr. 1.05 at 60°F/60°F means that the specific gravity of the binder is 1.05 when both the binder and the water are at 60°F).
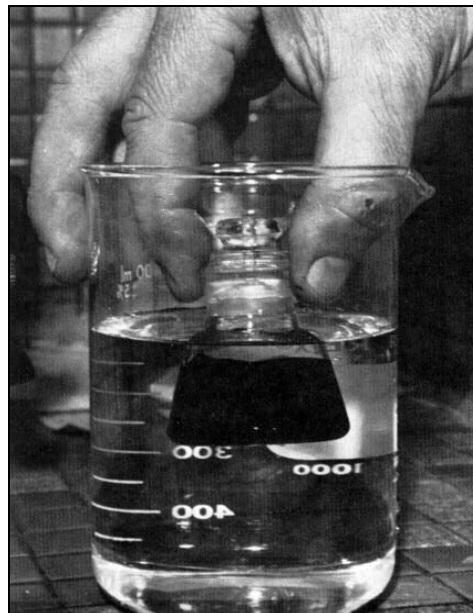

Figure 2-34. Determining Specific Gravity Using Pycnometer

Changes in volume of the binder may be a source for confusion in the plant when binder is required to be converted from weight to volume. When binder is shipped and stored, the basis of payment is weight. This procedure eliminates confusion in payment. However, binder in some plants is metered rather than weighed. When this occurs, the Technician is required to know how to convert weight to volume and volume to weight. The density or specific gravity of binder is the ratio of weight to volume at a specified temperature. Normally this temperature is 60° F. As the temperature of the binder increases the weight to volume ratio drops. If the binder is being metered, the density of the binder at 60° F and the temperature of the binder are required to be known. Also important to know is if the meter is compensating for this temperature and converting the registered volume back to 60° F. If not, then the binder content in the HMA is less than expected.

Another use of temperature volume relationships is to determine inventory. If the storage tank is gauged and a volume is determined then that volume is required to be reduced to a volume at 60° F. This value may then be converted to weight. Examples of converting a tank gauge volume to avolume at 60° F and then to a weight are as follows:

Example

Volume of binder is measured to be 6505 gallons at a temperature of 290° F. The specific gravity of the binder is 1.021. The volume of binder at the standard base temperature of 60° F is:

Volume correction factor of 0.9220 is read for the observed temperature of 290° F.

Vol. @ 60° F = Vol. @ (actual temp.) x Vol. Conversion Factor

Volume @ 60° F = 6505 x 0.9220
$\qquad$ = 5998 gallons

To convert volume at 60° F to Tonnage:

Tonnage = $\dfrac{\text{Vol. @ 60° F x Specific Gravity @ 60° F x 8.33 lb/gal}}{\text{2000 lb/t}}$

Tonnage = $\dfrac{5998 \times 1.021}{2000}$ x 8.33 = 25.5 t

GROUP O (°F)

GROUP O—SPECIFIC GRAVITY AT 60°F ABOVE 0.966

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oil volumes to the basis of 60°F

t	M	t	M	t	M	t	M	t	M
0	1.0211	50	1.0035	100	0.9861	150	0.9689	200	0.9520
1	1.0208	51	1.0031	101	0.9857	151	0.9686	201	0.9516
2	1.0204	52	1.0028	102	0.9854	152	0.9682	202	0.9513
3	1.0201	53	1.0024	103	0.9851	153	0.9679	203	0.9509
4	1.0197	54	1.0021	104	0.9847	154	0.9675	204	0.9506
5	1.0194	55	1.0017	105	0.9844	155	0.9672	205	0.9503
6	1.0190	56	1.0014	106	0.9840	156	0.9669	206	0.9499
7	1.0186	57	1.0010	107	0.9837	157	0.9665	207	0.9496
8	1.0183	58	1.0007	108	0.9833	158	0.9662	208	0.9493
9	1.0179	59	1.0003	109	0.9830	159	0.9658	209	0.9489
10	1.0176	60	1.0000	110	0.9826	160	0.9655	210	0.9486
11	1.0172	61	0.9997	111	0.9823	161	0.9652	211	0.9483
12	1.0169	62	0.9993	112	0.9819	162	0.9648	212	0.9479
13	1.0165	63	0.9990	113	0.9816	163	0.9645	213	0.9476
14	1.0162	64	0.9986	114	0.9813	164	0.9641	214	0.9472
15	1.0158	65	0.9983	115	0.9809	165	0.9638	215	0.9469
16	1.0155	66	0.9979	116	0.9806	166	0.9635	216	0.9466
17	1.0151	67	0.9976	117	0.9802	167	0.9631	217	0.9462
18	1.0148	68	0.9972	118	0.9799	168	0.9628	218	0.9459
19	1.0144	69	0.9969	119	0.9795	169	0.9624	219	0.9456
20	1.0141	70	0.9965	120	0.9792	170	0.9621	220	0.9452
21	1.0137	71	0.9962	121	0.9788	171	0.9618	221	0.9449
22	1.0133	72	0.9958	122	0.9785	172	0.9614	222	0.9446
23	1.0130	73	0.9955	123	0.9782	173	0.9611	223	0.9442
24	1.0126	74	0.9951	124	0.9778	174	0.9607	224	0.9439
25	1.0123	75	0.9948	125	0.9775	175	0.9604	225	0.9436
26	1.0119	76	0.9944	126	0.9771	176	0.9601	226	0.9432
27	1.0116	77	0.9941	127	0.9768	177	0.9597	227	0.9429
28	1.0112	78	0.9937	128	0.9764	178	0.9594	228	0.9426
29	1.0109	79	0.9934	129	0.9761	179	0.9590	229	0.9422
30	1.0105	80	0.9930	130	0.9758	180	0.9587	230	0.9419
31	1.0102	81	0.9927	131	0.9754	181	0.9584	231	0.9416
32	1.0098	82	0.9923	132	0.9751	182	0.9580	232	0.9412
33	1.0095	83	0.9920	133	0.9747	183	0.9577	233	0.9409
34	1.0091	84	0.9916	134	0.9744	184	0.9574	234	0.9405
35	1.0088	85	0.9913	135	0.9740	185	0.9570	235	0.9402
36	1.0084	86	0.9909	136	0.9737	186	0.9567	236	0.9399
37	1.0081	87	0.9906	137	0.9734	187	0.9563	237	0.9395
38	1.0077	88	0.9902	138	0.9730	188	0.9560	238	0.9392
39	1.0074	89	0.9899	139	0.9727	189	0.9557	239	0.9389
40	1.0070	90	0.9896	140	0.9723	190	0.9553	240	0.9385
41	1.0067	91	0.9892	141	0.9720	191	0.9550	241	0.9382
42	1.0063	92	0.9889	142	0.9716	192	0.9547	242	0.9379
43	1.0060	93	0.9885	143	0.9713	193	0.9543	243	0.9375
44	1.0056	94	0.9882	144	0.9710	194	0.9540	244	0.9372
45	1.0053	95	0.9878	145	0.9706	195	0.9536	245	0.9369
46	1.0049	96	0.9875	146	0.9703	196	0.9533	246	0.9365
47	1.0046	97	0.9871	147	0.9699	197	0.9530	247	0.9362
48	1.0042	98	0.9868	148	0.9696	198	0.9526	248	0.9359
49	1.0038	99	0.9864	149	0.9693	199	0.9523	249	0.9356

Figure 2-35. Temperature Volume Corrections for Binder

GROUP O continued (°F)

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oil volumes to the basis of 60°F

t	M	t	M	t	M	t	M	t	M
250	0.9352	300	0.9187	350	0.9024	400	0.8864	450	0.8705
251	0.9349	301	0.9184	351	0.9021	401	0.8861	451	0.8702
252	0.9346	302	0.9181	352	0.9018	402	0.8857	452	0.8699
253	0.9342	303	0.9177	353	0.9015	403	0.8854	453	0.8696
254	0.9339	304	0.9174	354	0.9011	404	0.8851	454	0.8693
255	0.9336	305	0.9171	355	0.9008	405	0.8848	455	0.8690
256	0.9332	306	0.9167	356	0.9005	406	0.8845	456	0.8687
257	0.9329	307	0.9164	357	0.9002	407	0.8841	457	0.8683
258	0.9326	308	0.9161	358	0.8998	408	0.8838	458	0.8680
259	0.9322	309	0.9158	359	0.8995	409	0.8835	459	0.8677
260	0.9319	310	0.9154	360	0.8992	410	0.8832	460	0.8674
261	0.9316	311	0.9151	361	0.8989	411	0.8829	461	0.8671
262	0.9312	312	0.9148	362	0.8986	412	0.8826	462	0.8668
263	0.9309	313	0.9145	363	0.8982	413	0.8822	463	0.8665
264	0.9306	314	0.9141	364	0.8979	414	0.8819	464	0.8661
265	0.9302	315	0.9138	365	0.8976	415	0.8816	465	0.8658
266	0.9299	316	0.9135	366	0.8973	416	0.8813	466	0.8655
267	0.9296	317	0.9132	367	0.8969	417	0.8810	467	0.8652
268	0.9293	318	0.9128	368	0.8966	418	0.8806	468	0.8649
269	0.9289	319	0.9125	369	0.8963	419	0.8803	469	0.8646
270	0.9286	320	0.9122	370	0.8960	420	0.8800	470	0.8643
271	0.9283	321	0.9118	371	0.8957	421	0.8797	471	0.8640
272	0.9279	322	0.9115	372	0.8953	422	0.8794	472	0.8636
273	0.9276	323	0.9112	373	0.8950	423	0.8791	473	0.8633
274	0.9273	324	0.9109	374	0.8947	424	0.8787	474	0.8630
275	0.9269	325	0.9105	375	0.8944	425	0.8784	475	0.8627
276	0.9266	326	0.9102	376	0.8941	426	0.8781	476	0.8624
277	0.9263	327	0.9099	377	0.8937	427	0.8778	477	0.8621
278	0.9259	328	0.9096	378	0.8934	428	0.8775	478	0.8618
279	0.9256	329	0.9092	379	0.8931	429	0.8772	479	0.8615
280	0.9253	330	0.9089	380	0.8928	430	0.8768	480	0.8611
281	0.9250	331	0.9086	381	0.8924	431	0.8765	481	0.8608
282	0.9246	332	0.9083	382	0.8921	432	0.8762	482	0.8605
283	0.9243	333	0.9079	383	0.8918	433	0.8759	483	0.8602
284	0.9240	334	0.9076	384	0.8915	434	0.8756	484	0.8599
285	0.9236	335	0.9073	385	0.8912	435	0.8753	485	0.8596
286	0.9233	336	0.9070	386	0.8908	436	0.8749	486	0.8593
287	0.9230	337	0.9066	387	0.8905	437	0.8746	487	0.8590
288	0.9227	338	0.9063	388	0.8902	438	0.8743	488	0.8587
289	0.9223	339	0.9060	389	0.8899	439	0.8740	489	0.8583
290	0.9220	340	0.9057	390	0.8896	440	0.8737	490	0.8580
291	0.9217	341	0.9053	391	0.8892	441	0.8734	491	0.8577
292	0.9213	342	0.9050	392	0.8889	442	0.8731	492	0.8574
293	0.9210	343	0.9047	393	0.8886	443	0.8727	493	0.8571
294	0.9207	344	0.9044	394	0.8883	444	0.8724	494	0.8568
295	0.9204	345	0.9040	395	0.8880	445	0.8721	495	0.8565
296	0.9200	346	0.9037	396	0.8876	446	0.8718	496	0.8562
297	0.9197	347	0.9034	397	0.8873	447	0.8715	497	0.8559
298	0.9194	348	0.9031	398	0.8870	448	0.8712	498	0.8556
299	0.9190	349	0.9028	399	0.8867	449	0.8709	499	0.8552

Temperature Volume Corrections for Binder (continued)

ASPHALT SUPPLIER CERTIFICATION PROGRAM

The Asphalt Supplier Certification Program (ASC) is a program in which a qualified asphalt supplier is allowed to manufacture and ship PG binders without complete pre-testing of the PG binder by INDOT or the supplier. PG binders are required to be supplied by an approved supplier in accordance with **ITM 581**.

PG binders that are shipped to HMA plants are required to have a shipping report indicating that the material was manufactured in accordance with the ASC program. Also, the supplier is required to furnish instructions with each PG binder concerning the proper storage and handling of the material.